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DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT D-77-42

AQUATIC DISPOSAL FIELD INVESTIGATIONS ASHTABULA RIVER DISPOSAL SITE, OHIO

APPENDIX A: PLANKTONIC COMMUNITIES BENTHIC ASSEMBLAGES, AND FISHERY

by

Robert A. Sweeney

Great Lakes Laboratory
State University College at Buffalo
Buffalo, New York 14222

July 1978

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for Office, Chief of Engineers, U. S. Army
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Under Contract No. DACW39-75-C-0110,
(DMRP Work Unit No. 1A08A)

Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESYV

31 July 1978

SUBJECT: Transmittal of Technical Report D-77-42 (Appendix A)

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of one of several research efforts (Work Units) undertaken as part of Task 1A, Aquatic Disposal Field Investigations, of the Corps of Engineers' Dredged Material Research Program. Task 1A was a part of the Environmental Impacts and Criteria Development Project (EICDP), which had as a general objective determination of the magnitude and extent of effects of disposal sites on organisms and the quality of surrounding water and the rate, diversity, and extent such sites are recolonized by benthic flora and fauna. The study reported herein was an integral part of a series of research contracts jointly developed to achieve the EICDP general objective at the Ashtabula, Ohio, site in Lake Erie, one of five sites located in several geographical regions of the United States. Consequently, this report presents results and interpretations of but one of several closely interrelated efforts and should be used only in conjunction with and consideration of other related reports for this site.

2. This report, Appendix A: Planktonic Communities, Benthic Assemblages, and Fishery, is one of three contractor-prepared appendices published relative to Waterways Experiment Station Technical Report D-77-42 entitled Aquatic Disposal Field Investigations, Ashtabula River Disposal Site, Ohio. The titles of all contractor-prepared appendices of this series are listed on the inside front cover of this report. The main report will provide additional results, interpretations, and conclusions not found in the individual appendices and provide a comprehensive summary and synthesis overview of the entire project.

3. The purposes of this study, conducted as Work Unit 1A08A, were to evaluate the natural temporal variations within the lacustrine flora and fauna within the study area, to document the initial impact of dredged material disposal on the flora and fauna, to evaluate the longer term effects of the disposal operations, and to document recolonization and recovery of benthic communities impacted by disposal. The report includes a discussion of the effects of dredged material disposal on phytoplankton, zooplankton, and fishery communities as well as the effects on benthic fauna. Plankton nets, gill nets, and fathometer tracings were used to assess plankton and fish populations while box core samples were taken for benthic enumerations.

WESYV 31 July 1978

SUBJECT: Transmittal of Technical Report D-77-42 (Appendix A)

4. A conclusion of this report, based on the data presented, was that the pelagic biota were only mildly affected in the area of disposal and that recovery was relatively rapid except possibly in the bottom waters directly influenced by the dynamics at the sediment-water interface. In addition, disposal impacts on adult and young-of-the-year nektonic organisms were limited to a short-term avoidance of the physical disturbance. Mid-water and surface-dwelling fish species were observed to enter the plume created by disposal with little or no apparent avoidance. Bottom-dwelling fishes moved a distance of at least 300 m from the disposal area, returning to the disposal area within 1 hour.

5. The evaluations at all of the EICDP field sites were developed to determine the base or ambient physical, chemical, and biological conditions at the respective sites from which to determine impacts due to the subsequent disposal operations. Where the dump sites had historical usage, the long-term impacts of dumping at these sites could also be ascertained. The results of this study are important in determining placement of dredged material for open-water disposal. Referenced studies, as well as the ones summarized in this report, will aid in determining the optimum disposal conditions and site selection for either the dispersion of the material from the dump site or for its retention within the confines of the site, whichever is preferred for maximum environmental protection at a given site.

John L. Cannon

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESEV

20 November 1978

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Errata Sheet

No. 1

AQUATIC DISPOSAL FIELD INVESTIGATIONS, ASHTABULA RIVER DISPOSAL SITE, OHIO; APPENDIX C: INVESTIGATION OF WATER-QUALITY AND SEDIMENT PARAMETERS

Technical Report D-77-42

July 1978

Page 131, LITERATURE CITED. Authorship of the tenth item should be changed to read:

Danek, L.J., G.R. Alther, P.P. Paily, R.G. Johnson, F. de Libero, J.F. Yohn, and F.T. Lovorn.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An investigation to evaluate impacts of the release of dredged material on phytoplankton, zooplankton, benthic macroinvertebrates, and fish was conducted in Lake Erie off Ashtabula, Ohio, from June 1975 through September 1976. Samples and measurements were taken prior to, during, and after the release of materials from a hopper dredge during August 1975 and May 1976. CONT

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20. ABSTRACT (Continued).

CONT'

The pelagic biota (phytoplankton, zooplankton, and fish) along with primary productivity were only mildly impacted and recovery was relatively rapid. The benthic communities were altered with the decline of some species and introduction of new fauna transported from the dredged sites. Within a year species diversity had largely returned to predisposal levels. However, the community structures were slightly altered. These changes were similar to those noted in marine environments exposed to dredged material.

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PREFACE

This report presents the results of an investigation to determine the baseline conditions of the phytoplankton, zooplankton, benthos, and fish populations at the Ashtabula Disposal Site, Lake Erie, Ohio. The study was prepared for the Office, Chief of Engineers, and supported by the U. S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL), Vicksburg, Mississippi, under Contract No. DACW39-75-C-0110 to the Great Lakes Laboratory, Buffalo, New York. The report forms part of the WES Dredged Material Research Program (DMRP). Contracting was handled by the DMRP.

The initial draft of the basic report was prepared by R. Warren Flint while the final report was written by Robert Sweeney of the Great Lakes Laboratory. The following Great Lakes Laboratory personnel assisted in the collecting, sorting, analysis, and identification of samples and data reduction: David Barto, Roberta Cap, Mark Evanko, Thomas Kirby, Joseph Kubiak, Leslie Lechot, Paul Letki, George Lorefice, Debra Marzec, Patrick McMahon, Charles Rottel, Richard Svennson, Vincent Tabone, Paul Tranchell, Carol Welsh, and Berry Wech. Andrew M. White of the Cleveland Environmental Research Group conducted the study on the effects of dredged material disposal on fishes which is reported in Appendix A'.

Contract Manager for EL was Charles G. Boone. The study was under the supervision of Dr. Robert M. Engler, Manager of the DMRP Environmental Impacts and Criteria Development Project, and the general supervision of Dr. John Harrison, Chief, EL.

Director of WES during the conduct of this study and preparation of the report was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

The U. S. customary units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers

AQUATIC DISPOSAL FIELD INVESTIGATIONS

ASHTABULA RIVER DISPOSAL SITE, OHIO

APPENDIX A: PLANKTONIC COMMUNITIES, BENTHIC ASSEMBLAGES, AND FISHERY

PART I: INTRODUCTION

Background

1. There are numerous major commercial water routes throughout the United States that require periodic dredging if they are to be kept navigable. These include Great Lakes harbors and rivers that, to be maintained for commercial use, must be selectively deepened periodically through dredging. Dredging is a process by which sediments are removed from the bottom of streams, lakes, and coastal waters, transported via ship, barge, or pipeline, and discharged to the land or water (U. S. Army Corps of Engineers 1976). Dredged material can consist of a wide range of substances, including those contaminated by industrial, urban, and agricultural activities. As a consequence, there may be considerable differences in the quality of dredged material between and within harbors and tributaries.

2. In the past there has been much nationwide concern over the environmental effects of dredged material disposal. There have been a number of large-scale surveys of the effect of dredged material disposal on the aquatic environment. Many of these have been conducted in marine habitats (Brown and Clark 1968, Pfitzenmeyer 1970, Sykes and Hall 1970, Sailia, Pratt,and Polgar 1972, Windom 1972), however, and have produced varied results. Few results have been reported from ecological studies of a similar nature conducted in freshwater habitats. The variations in predictions of the potentital effects of disposal on the biota and on water quality in the marine investigations (Sherk 1971, Thompson 1973) suggest that impacts observed in any environment (marine or fresh water) must depend upon local sediment regime, water quality, and biotic assemblages present.

3. It is well known that, depending on individual circumstances, bottom sediments are continuously being resuspended by natural processes. In contrast to the natural phenomenon of sediment resuspension, however, open-water disposal often results in the resuspension of large volumes of sediments over a relatively short period of time in a very small area. In addition, possible direct effects of open-water disposal of dredged material include sediment buildup, changes in spawning grounds, reduced habitat diversity, and changes in sediment-water chemical interactions. Furthermore, since much of the sediments in the nation's waters have become contaminated with chemical pollutants, there are possibilities that the artificial resuspension (disposal) of such sediments may increase the availability of these pollutants, particularly to the bottom biological communities. The end result of these potential effects are directly felt by man because, in most cases, the entire trophic web of a lacustrine community may be impacted by the changes described above.

4. By the River and Harbor Act of 1970 (Public Law 91-611, Section 123 (i)), the U. S. Army Engineer Waterways Experiment Station (WES) was given the responsibility of evaluating the exact impact of open-water dredged material disposal on the aquatic environment. In order to accomplish these directives the Dredged Material Research Program (DMRP), as part of the Environmental Laboratory (EL), was created. As part of this responsibility, the DMRP contracted the Great Lakes Laboratory (GLL) of the State University College at Buffalo, N.Y., to conduct a research program in Lake Erie, off Ashtabula, Ohio, to assess the effects of dredged material deposition in fresh water. The overall objective of the research program developed by the Corps and the GLL was to provide, through surveys and experimentation, definitive information on the environmental impact of dredged material disposal operations and to develop technically sound, environmentally compatible, and economically feasible disposal procedures.

Objectives

5. The ecological impact of the discharge of dredged material can be divided into two main categories: physical effects and chemical-biological

interactive effects. Physical effects are often straightforward, and evaluation may often be made by examining the type and quantity of material being disposed and relating these conditions to the sediment of the prospective disposal site. Many of the chemical-biological interactive effects resulting from disposal, however, may be more complicated and subtle. These are difficult to predict. This study on the effects of open-water dredged material disposal at the Ashtabula Disposal Site will deal specifically with the biological results obtained from the research program and will discuss them in general terms with respect to impacts of disposal. The planktonic communities and the benthic assemblages are discussed in the main text; the discussion on fishery, which was prepared by a subcontractor, is contained in Appendix A'.

6. The specific objectives of the study were to:

- a. Report natural temporal variations within the lacustrine flora and fauna in the immediate area of investigation.
- b. Document the initial impact of dredged material disposal on the flora and fauna.
- c. Evaluate long-term effects of the disposal event on the biota.
- d. Document recolonization and/or recovery of benthic communities impacted by disposal.
- e. Study the mechanisms controlling benthic recovery, especially faunal distributions.
- f. Relate the results to natural floral and faunal abundances and reproduction cycles in the area.
- g. Provide additional information relevant to the planning of dredged material disposal operations.

PART II: SITE DESCRIPTION

Location

7. The Great Lakes region chosen by WES for the investigation of open-water disposal of dredged material under the DMRP was located in the nearshore waters (less than 19 m) of Ashtabula, Ohio. Located in the northeastern corner of the state, Ashtabula Harbor is a major coal transfer port on the Great Lakes and handles a large volume of commercial traffic. As a product of both naturally occurring and man-induced circumstances, the Ashtabula River and Harbor require almost annual dredging operations in order to keep the main channels of the Harbor and River open to this commercial traffic.

Geology

8. Ashtabula Harbor is located in Ashtabula County, which is part of the Allegheny Plateau section on the northwestern edge of the Appalachian Plateau. A steep escarpment consisting of Mississippian and Pennsylvanian sediments is located about two miles south of Ashtabula and characterizes the topography of the area. (A table of factors for converting U. S. customary units of measurement to metric (SI) can be found on page v). The geological formations that comprise the Allegheny Plateau include Ohio shales formed during the Devonian period. Fragments of this fossil shale were found in most clay fractions of the sediments in the Ashtabula vicinity (Danek et al. 1976). This suggested that the Ohio shale was the parent rock for the soils and that the shale had eroded through glacial abrasion. Large shale fragments also characterized areas of the proposed disposal site, located approximately two miles north of the Harbor mouth. Superficial sediment materials in the general area consisted of alternating and mixed layers of mud, silt, sand, and compacted sand with pebbles.

Dredging Activities

9. The earliest documented records of dredging activity in the

Harbor by the U. S. Army Corps of Engineers (CE) and other contractors date back to 1909. With the exception of 1972, the Harbor has been dredged yearly since 1945. Prior to the GLL's investigations beginning in 1975, 3.3×10^6 m^3 of earth and 6.4×10^5 m^3 of rock had been removed from the Harbor and River areas since annual dredging operations began. All dredged material was disposed of in the open-lake environment in either the earth or rock disposal areas as shown in Figure A1. The 1975 and 1976 dredging activities resulted in disposal of an additional 2.4×10^5 and 8.7×10^4 m^3 of sediment, respectively.

Sampling

10. Station locations. The study area consisted of stations within a 2.6-km^2 region which incorporated the official earth dump area (designated by the U. S. Army Corps of Engineers). In order to characterize this area as well as a Reference Area of equal size (Figure A2), with similar Lake characteristics (depth, distance from shore, sediment type, etc.), an Initial Survey was conducted on 11 and 12 June 1975. This survey consisted of the collection of duplicate Ponar grab samples from 9 stations in the Reference Area and 16 stations in the Disposal Area (Figure A3). These samples were analyzed for percentage of group composition and total number of organisms per square meter. The results of these analyses (means of two Ponar grabs) are presented in Table A1. Examination of the group compositions indicated that the bottom habitat was extremely heterogeneous in terms of faunal community types. Oligochaetes did not totally dominate the communities on most sites. The chironomids also exhibited quite a variation between sites. Total numbers of organisms (Table A1) were relatively similar among all samples taken in the Reference Area, but there was considerable variation in this measure observed regarding the Disposal Area samples. The chironomids were very numerous in the samples made during this period. The isopods appeared in much higher numbers in the Reference Area than in the proposed Disposal Area. The sphaeriids also showed this trend, especially at Stations B1, B2, and B6 (Figure A3).

11. Biological events. After fully evaluating these results as well as those characterizing the physical (Danek et al. 1976) and chemical (Great Lakes Laboratory 1977) benthic environment, specific sites within the Reference and Disposal Areas (Figure A3) were chosen to monitor the biological events that occurred following disposal. The first experimental benthic site selected was at Initial Survey Station B13. This station was labeled D2 and was used for the monitoring of the disposal of dredged material taken from Ashtabula Harbor. Additional benthic sampling stations (D1, D3-D6) were selected in the immediate vicinity of Station D2 (Figure A4) to evaluate effects of disposal in the surrounding area as well as down-current from the site of disposal of Harbor material. On-site current information was provided by NALCO.

12. The second center benthic site selected to monitor disposal was at Initial Survey Station B24. This site was used as the target for disposal of dredged material removed from the Ashtabula River. This experimental site was designated D8 (Figure A4). Additional benthic stations were chosen in the immediate area of D8 (D7, D9-D12) for the purposes described above.

13. Reference sites for the study were selected at Initial Survey Stations B1 and B7 (Figure A3), and labeled C1 and C3, respectively. Two additional reference sites were selected in the immediate vicinity of the first two and labeled C2 and C4 (Figure A4).

14. Based on the results of the Initial Survey of the benthic community structure, there was some question as to the suitability of the Reference Station C1. As illustrated in Table A1, this location (B1) supported an extremely high number of sphaerids, a trend that was observed throughout the study. Similar sediment types, however, plus the fact that core samples rather than Ponar grabs would be taken for all future benthic collections were significant considerations made in the selection of the reference sites. It was necessary to use a K-B corer rather than a Ponar in order to ascertain the benthos distribution with depth.

15. The benthic disposal site chosen for the second year of study was located near the Initial Survey Station B10 (Figure A3). Again, there

was some question, based upon the benthic community analyses, of the suitability of this location in respect to the reference station sites. Physical conditions, however, were considered to be most important in site location. This northwest site was labeled NDS (Figure A4). The final selection of all stations also was based on the close proximity of collection areas, with enough distance so that reference stations would not be affected by events occurring on another (disposal). As indicated by the extreme biological heterogeneity of the benthic environment in this area, it was not possible to establish identical sampling stations, except in extremely restricted areas.

16. Pelagic samples. The Initial Survey of this area (10-11 June) also included the collection of pelagic samples for phytoplankton and zooplankton enumeration. These collections were made in triplicate at Stations SPW1-SPW7 (Figure A5). The results of phytoplankton analyses (Figure A6) showed a range of 648 cells/mℓ at SPW7, the nearest location to shore, to 1032 cells/mℓ at SPW1, the deepest of the sampling sites. Group compositions (Figure A6) were very similar. The Cryptophyta was the dominant group observed. *Rhodomonas minuta* and *Cryptomonas erosa* were the major species represented. The flagellates also were relatively abundant in this area.

17. Zooplankton results (Figure A7) illustrated the difference in collection sites nearer shore to a greater extent than the phytoplankton observations. The total numbers of adult crustacean zooplankton observed at Stations SPW5 and SPW6 were higher than the other samples. This higher abundance at SPW5 and SPW6 was a trend that was seen throughout the investigation both for zooplankton and phytoplankton variables. The cladocerans were dominated by bosminids. The copepods were comprised primarily of cyclopoids while the calanoids were represented in fairly small numbers, a pattern observed throughout the study duration. Group compositions were very similar between stations while only the total number varied, as also seen with the phytoplankton.

18. After evaluating these results, which indicated heterogeneity within the water column with minor influences from conditions typical for shallower waters, 11 pelagic stations were chosen for monitoring the

impact of dredged material disposal on the pelagic environment. These pelagic stations were divided into Reference, Disposal, and additional sites in an attempt to follow changes in the general area. Reference Stations PW1 and PW2 (Figure A8) coincided with the benthic Reference Stations C1 and C3 (Figure A4) while pelagic Stations PW3 and PW5 were located above benthic Disposal Stations D2 and D8, respectively. The remainder of the pelagic stations (PW4, PW6-PW11) were selected to evaluate changes in the environment down-current from the disposal sites as well as in the general nearshore area of Ashtabula (Figure A8). For the 1976 disposal monitoring an additional pelagic site, NDS, was selected, which was located over the benthic NDS site, the center of disposal for 1976. Location (latitude and longitude) and depth of all Reference and Disposal stations described in this section are shown in Table A2.

PART III: EXPERIMENTAL DESIGN AND SAMPLING SCHEME

19. As described in the previous section, the Reference and Disposal Areas were established after an Initial Survey was conducted on the nearshore waters of Ashtabula, Ohio. A long-term monitoring program was developed in 1975 to evaluate the impact of dredged material disposal within this area. The results of this long-term investigation stimulated a more intensive study of the short-term effects of disposal in 1976. This short-term evaluation was conducted on the northwest disposal site (NDS), described in the previous section.

20. Initially, in order to characterize the types of materials being deposited at the disposal sites, benthic samples were taken at 15 River and 15 Harbor stations (Figure A9) in duplicate on 24 June 1975. K-B cores were made at each site and the samples analyzed taxonomically for benthic macroinvertebrate fauna. The mean results per station results were compared to data collected on the Lake benthic sites both prior to and after disposal.

21. A summary of sampling intervals and activities is presented in Table A3. The biological variables measured during the sampling intervals are illustrated in Table A4. Specific treatments, such as benthic core sectioning, as well as actual stations sampled, are included in Table A4.

22. Predisposal collections were made at the 1975 reference and experimental sites designed for study of long-term disposal effects on 9-11 July 1975 and 30-31 July 1975. Stations were located using buoys placed by NALCO. The first predisposal collections were only made on the pelagic stations (PW1-PW11) for phytoplankton enumeration, primary productivity, chlorophyll a measurements, and zooplankton enumeration. The zooplankton samples were not preserved adequately in the field and partially decomposed before counting; thus, data concerning this group were not reported. The second 1975 predisposal collections (30-31 July) included the variables mentioned above for the 11 pelagic stations plus benthic samples taken at all 16 benthic stations (C1-C4, D1-D12).

23. On 4 August 1975, dredging operations in the Harbor and River

began. These operations were carried out using the U. S. Army Corps of Engineers Hopper Dredge Markham. During the disposal events, chlorophyll a was chosen in an attempt to measure impacts of disposal operations on the pelagic biota. Samples for pigment analysis were taken from both anchored and moving vessels during the disposal operation at both Station PW3, the Harbor dredged material disposal site, and Station PW5, the River dredged material disposal site. Single samples were collected using anchored small boats at 1 m below the surface and 1-2 m above the bottom at 50, 100, 150, and 300 m away from the Disposal Site. Boats were positioned using an electronic navigation system operated by NALCO. These Van Dorn collections were made at times of 0, 15, 30, 45, and 60 min after commencement of deposition. Uniformity of the collections with respect to depth and time was maintained by means of oral directions to those doing the sampling. Following each disposal, samples were transported by other craft to shore for splitting and preservation.

24. Postdisposal monitoring was conducted over a month interval to estimate the longer term impact on the lacustrine biological communities. Collections to measure changes in the flora and fauna were initiated on 14 August 1975, immediately upon completion of disposal operations. Only the pelagic variables were measured during this period. The remaining postdisposal samplings were conducted through the fall season as long as the area was free of ice cover and the weather was favorable. Collections of both sediments and water for biological analyses were made using K-B Corers and Van Dorns, respectively, at all stations on 19-20 August, 14 September, and 15-16 November during 1975 (Tables A3 and A4). Pelagic samples were taken in triplicate and four replicate benthic samples were collected at each site. Additional collections were made only at the pelagic stations on 19 October 1975. In 1976, due to limitations in time and funding, the number of sampling sites had to be reduced. The 1976 sampling was designed to estimate the longer term impact of dredged material disposal. Pelagic stations that were sampled included PW1, PW2, PW3, and PW5. The NDS pelagic site (Figure A8) also was sampled for the first time as preparation for the 1976 disposal operation. Benthic collections in 1976 were made at C1, C3, D2, D3, D8, and D9 (Figure A4). The 1976 sampling intervals, a continuation of 1975 long-term monitoring,

were 21 April and 7-8 July. As indicated in Table A4, the benthic sediment cores taken between 30 July 1975 and 8 July 1976 at C1, C3, D2, and D8 were sectioned into at least three sections per core depending on core length (0-5, 5-10, 10-20, and > 20 cm).

25. In addition to revisiting some of the original stations in 1976, the monitoring of another disposal event was planned. The design included more intensive sampling in an effort to evaluate short-term disposal effects on the biota. The benthic fauna were the major focus. Elutriate primary productivity bioassays were initiated to better characterize specific disposal impacts on the pelagic biota. The Northwest Disposal Site (NDS) was utilized during this operation (Figure A4). A 16-point grid (400 m x 400 m) was established which centered around NDS as shown in Figure A10. The sixteen 100-m^2 areas, labeled Quadrats SD1-SD16, with collection sites located at the centers of each, were sampled on 15-16 May 1976 along with the pelagic Stations PW1, PW2, PW3, PW5, and NDS. This event constituted the predisposal monitoring for the 1976 disposal operation and also an additional postdisposal 1975 collection for the pelagic stations. In addition, during this period, five sites in the Ashtabula River, the source of dredged material for 1976, were sampled in duplicate for benthic macroinvertebrate analysis. This was done to establish background information on the material to be disposed on NDS.

26. The only biological observations made during the 1976 disposal event were a series of benthic sediment cores (three) and fish tracings taken prior to hopper release on the second day of disposal and another series (three) following completion of disposal, the same day. These sediment cores were taken in Quadrat SD10 (Figure A10). The 1976 postdisposal collections were made on 10-11 June and 7-8 July 1976 from all 20 sediment sites (C1-C4, SD1-SD16) and the 5 pelagic sites (Tables A3 and A4). The only significant changes in the 1976 collections, contrasted to 1975, were the taking of only two replicate sediment cores per site and two replicate samples per pelagic station. The cores from C1, C3, SD7, and SD11 were segmented into only three sections/core (0-5, 5-10, and > 10 cm). In addition to the above, as already mentioned, elutriate-

primary productivity bioassays were conducted on four occasions, 15-16 May, 10 June, 27 July, and 14 September of 1976 (Table A4).

PART IV: METHODS

27. The effects of the disposal of dredged material can be reflected in alterations in the population density, species composition, physiological condition, and metabolic rates of natural aquatic communities. Methods for the field surveys and long-term, water-quality monitoring described below, therefore, are directed primarily toward organism identification and quantification as well as the measurement of metabolic rates. These methods will be used in comparative evaluations between the Reference Sites and the Dredged Material Disposal Sites.

Phytoplankton Enumeration

28. At each pelagic station, the percent transmittance of surface light was measured at one-meter depth intervals through the water column with a submarine photometer (Kahlsico #286WA310). From this procedure the depths for 25 and 1% transmittance were determined. A water sample was collected at 1 m below the surface and at each of the above transmittance depths using an 8-ℓ Van Dorn water sampler. The water from all 3 depths was subsampled (75 mℓ each) to give a composite sample representing the entire water column (as deep as 1% light transmittance). This composite sample was collected in triplicate (three separate drops of Van Dorn) at each of the pelagic sites during 1975, while duplicate samples were collected during 1976. The plankton in each sample were preserved with modified Lugol's solution (Vollenweider 1969).

29. In the laboratory, the taxonomic identification and enumeration were done using an inverted microscope according to the method of Utermöhl (1958) as modified by Lund, Kipling, and LeCreu (1958) and Munawar (1972). Depending on phytoplankton density, preserved collections were shaken and aliquots of 10-50 mℓ were taken from each and placed in settling chambers. After settling 24 hr, they were examined with an inverted microscope (Wild Model M40 - Phase Contrast). The raw counts for the phytoplankton taxonomic groups identified to species were expanded to cells per milliliter and reported for each replicate sample from each

pelagic site.

30. Taxonomic identification was facilitated by reference to several keys and monographs that are listed for the major taxonomic groups in Appendix A1.

Pigment Analysis

31. The water samples taken at each pelagic station for phytoplankton, including 1 m below the surface and 25 and 1% light transmittance, were also subsampled for measurement of phytoplankton pigments. Like phytoplankton, triplicate subsamples were taken at each depth. These were filtered through Whatman GF/C glass-fiber filters (0.45 μ) to which five drops of magnesium carbonate were added. The filters were kept frozen in the dark until laboratory analysis.

32. Filters were homogenized in 90% basic acetone and centrifuged for 10 min after a minimum of 2 hr extraction in the dark (Glooschenko, Moore, and Vollenweider 1974). After centrifugation, the pigments were spectrophotometrically determined (Beckman DB-GT Spectrophotometer) by the methods of Strickland and Parsons (1972), and phaeopigments were determined by the method of Lorenzen (1968). The results of the pigment analyses were expressed as milligrams chlorophyll a per cubic meter of the water column.

Measurement of Primary Productivity

33. Primary productivity estimates were obtained at the same pelagic stations where phytoplankton enumeration and pigment analyses were performed. Water samples were collected with a Van Dorn water sampler at 1 m below the surface and at the depth of 25% light transmittance. During this study the latter occurred at 2.3 or 5 m. Collections were placed in triplicate 125-ml ground glass-stoppered Pyrex bottles (two clear and one opaque). Two of these triplicate sets (three separate Van Dorns) were taken at each depth.

34. Rates of primary productivity were measured by the ^{14}C technique

(Steemann-Nielsen 1952, Goldman 1963, Vollenweider 1969). A 1.0-mℓ solution of ^{14}C predominantly labeled as sodium bicarbonate was injected into each sample bottle. The isotope was of known radioassay as determined through previous scintillation counting. The samples were then resuspended at the depth of original collection and allowed to incubate for 2 hr. After incubation the samples were fixed with 1 mℓ of neutral formalin and transported in a light-free box to the laboratory. The samples were filtered through 0.45-μ membrane filters. After partial drying the filters were placed in scintillation vials containing 15 mℓ of Insta-Gel (Packard) and kept at 0°C to minimize evaporation. The radioactivity of the filters was determined on a Packard Tri-Carb 3320 Liquid Scintillation Spectrophotometer with a maximum of 10 min counting for each sample. Calculation of autotrophic assimilation followed standardized procedures used for phytoplankton (Vollenweider 1969).

35. A factor was derived for that portion of the total solar radiation received (Belfort Pyrheliometer: Belfort Instrument Co., Baltimore, Maryland) during the in situ incubation period to permit extrapolation to daily photosynthesis rates if required. Total available inorganic carbon was calculated from sample temperature, alkalinity (determined by titrations), pH, conductivity, and appropriate conversion factors (Saunders, Trama, and Bachman 1962). Results of primary productivity were expressed in milligrams of carbon per cubic meter of the water column per hour.

Elutriate-Primary Productivity Bioassay

36. Sediment samples were obtained using a Ponar grab while water samples were taken with a Van Dorn water sampler. The dredged material elutriate water was prepared from these as described by the GLL (1977). In addition, for each experiment 5 ℓ of lake water was filtered through 0.45-μ membrane filters to remove all phytoplankton. On each occasion that the elutriate-primary productivity bioassays were conducted, a large volume of lake water was taken within the Reference Area at 1-m depth and mixed into a composite sample. From this composite, sets (two clear and one opaque) of 125-mℓ ground glass-stoppered Pyrex bottles were filled.

These incubation bottles were divided into treatment groups, each group containing three sets of bottles. The bottles each had 25 mℓ of water removed with a continuous syringe.

37. Treatment levels were established using the dredged material elutriate, the sets of lake water samples from 1 m, and the filtered lake water. The following treatment levels were used in the bioassays:

Number of Light Bottle	Number of Dark Bottle	Elutriate Added mℓ	Filtered Lake Water Added mℓ
6	3	0	25.0
6	3	0.1	24.9
6	3	1.0	24.0
6	3	5.0	20.0
6	3	10.0	15.0
6	3	15.0	10.0
6	3	25.0	0.0

38. After addition of the filtered lake water and elutriate to each group of treatment bottles, the bottles were inoculated with 1.0 mℓ of $NaH^{14}CO_3$, randomly placed in the bottle holders, and incubated in the Lake at 1 m for a 4-hr incubation period. After incubation the photosynthesis was stopped with 1.0 mℓ of neutral formalin, and the samples were filtered through membrane filters (0.45 μ). The filters were placed in scintillation vials containing Insta-Gel and counted in the laboratory according to the procedure described above for primary productivity measures.

39. Activity of the phytoplankton cells, as measured by the scintillation counting, was used to measure the photosynthetic response of the organisms. Total counts of the reference samples (no addition of dredged material elutriates) were considered as normal photosynthesis. Radioactive counts for the various dilutions of elutriate were compared to the references. The dark bottle elutriate results were found to be especially valuable because they also accounted for any heterotrophic activity that may have influenced the final result. Thus, the heterotrophic activity could be measured and subtracted to ascertain the impact

on phytoplankton productivity.

Pelagic Zooplankton Enumeration

40. Samples were taken at each of the pelagic water stations through triplicate hauls of unmetered plankton nets with a mouth diameter of 40 cm and a mesh size of 64 μ. Net hauls were made according to the methods of Davis (1969) and Patalas (1972). Vertical hauls were made from 1 m above the bottom to the surface at each station. The collections were concentrated in a Wisconsin plankton bucket by washing, the buckets washed into jars, and the samples preserved in 10% buffered formalin and 5% glycerin.

41. In the laboratory taxonomic identifications to the species level, if possible, and estimations of abundance of crustacean zooplankton were performed using a compound microscope (Bausch and Lomb Stereo Zoom 7). A minimum of 200 animals, excluding copepod nauplii, were counted for each sample as per Patalas (1969) and Watson and Carpenter (1974). Numbers per cubic meter of the water column were calculated from the volume of the subsample counted, assuming a plankton net efficiency of 100% (collection of all organisms in the water column), depth of tow, and net diameter. The values from the triplicates were averaged to obtain the results per station.

42. Taxonomic identification of the different crustacean zooplankton groups was aided by reference to several keys listed in Appendix A1.

Benthic Invertebrates

43. At each benthic station or within each quadrat (depending on year of sampling) samples were obtained from the bottom sediments using a General Oceanographics box corer with a surface sampling area of 151.56 cm^2. During the 1975 cruises four replicate benthic samples per box corer sample were taken at each station. For the NDS in 1976, the benthic sampling was reduced to two replicates per quadrat. The samples were removed from the box corer and separately sieved through #30 mesh United States Geologic Survey sieves. The organisms and any remaining

material were washed from the screen into jars and preserved in 10% neutral formalin and 5% glycerin. In cases where the cores were to be examined for vertical distribution of organisms the core was extruded into a wooden frame and sectioned with horizontal slats at the vertical intervals of 0-5, 5-10, 10-20, and > 20 cm. During 1976 the intervals were reduced to three intervals (0-5, 5-10, and > 10 cm). Each section was then sieved separately and preserved according to the above.

44. For meiobenthic invertebrate fauna (fauna passing through the #30 mesh screen and retained on the #60 mesh screen), a subsample was removed from the box corer sample using a 4.8-cm-diam Plexiglas tube. As with the macrobenthic enumeration, four replicate samples were taken for meiobenthic examination in 1975 and two replicates were taken in 1976. The total samples were extruded into jars and preserved in 10% formalin and 5% glycerin for sieving later in the laboratory. Samples that required sectioning were partitioned on the boat as above and then preserved in sample jars.

45. In the laboratory the sieved samples were stained with Rose Bengal, sorted, picked using a Stereozoom binocular microscope (Bausch and Lomb Model BV8-73), and preserved in 70% ethanol according to the methods of the Environmental Protection Agency (EPA) (1973). The meiobenthic samples were sieved in the lab through standard #30 and #60 mesh sieves. The fauna retained by the #60 mesh were treated in the same manner as the macrobenthic fauna for sorting.

46. Oligochaetes were mounted in Amman's lactophenol solution and identified using Brinkhurst and Jamieson (1971) and Hiltunen (1973), both descriptive keys for this group. A maximum of 100 oligochaetes were keyed to species. Numbers were corrected for core length and converted to organisms per square meter of bottom area.

47. The chironomids were sorted, the heads removed, and then the entire animal mounted in glycerin for identification to the species level, if possible. All organisms were keyed using the description of Mason (1973). The nematodes were mounted with CMCP 9AB and identified according to Ferris et al. (1973). The remainder of the fauna in the samples were examined under the stereo microscopes and keyed. Numbers of all taxonomic groups were expressed in terms of square meter of the

bottom.

48. Taxonomic identification of the major groups, excluding the oligochaetes, chironomids, and nematodes was facilitated by the use of keys listed in Appendix A1.

Data Analysis

49. A principal components analysis (community ordination) was performed on the phytoplankton and zooplankton analyses to aid in the interpretation of the differences between the Reference and Dredged Material Disposal Sites. Although the major impact from disposal was expected on the benthic environment, it was believed that effects might occur in the biota of the overlying water from recycling and resuspension processes. The principal components presented a useful means of examining the data from the taxonomic analyses. It represented the communities with similar records by close positioning of points on a two-dimensional plot. Communities with dissimilar characteristics were plotted at a distance from one another. The function of the principal components process was to reduce the intangible sample n-space to a space whose dimensions were much less than n and yet preserve as much similarity/dissimilarity information as possible. The assumption was that the position of points or cluster of points along a graphical axis may reflect community relationships. The similarity index used was Euclidian distance (Anderberg 1973). The above method also was used on the benthic invertebrate faunal list for each station for each sampling date to identify varying differences over time between the Disposal and Reference Sites. The method of community ordination used here was based on the principal component analysis (Orloci 1966). The analyses were performed using a modified version of a FORTRAN program developed by Donald Young* and run on the State University of New York (SUNY) IBM 360 computer.

50. A discriminant analysis routine was also used on the total

* Personal Communication, ____ 1976. Donald Young, Research Associate, The Ohio State University, Columbus, Ohio.

numbers of major benthic taxonomic groups observed at each site in order to distinguish statistical differences between the sites chosen a priori as defined by their various communities. The objective of using this statistical analysis procedure serves as an index for discriminating between groups. In this manner, Reference and center Disposal Site data could be discriminated by new variates that would differentiate them as statistically distinct from one another as possible. After these groups were analyzed and their discriminant functions defined, the remaining Experimental Sites were classified into one of the two groups based on community similarities. This information provided an evaluation of the actual size of the area impacted by disposal and the recovery of sites with time which were not as impacted as the center areas. Stepwise calculations were made in order to identify the variables most significant in contributing discriminatory power to any sites that showed differences from others. All computations were made to a significance level of $P \leq 0.05$. The analyses were done on the IBM 360 computer using the Statistical Package for Social Sciences (SPSS) Discriminant Analyses (Nie et al. 1970).

51. A one-way analysis of variance was used to test for significant differences among treatment levels of the elutriate primary productivity experiment. The analysis of variance summary table provided the F-ratio and test of significance for variance between the several groups (concentrations of elutriate addition). The results were considered significant at $P \leq 0.05$. A priori contrasts were also specified for each of the elutriate addition groups with the control groups and tested by the Dunnett's +/- statistic. A test for homogeneity of variances was used (Dunnett F) to determine whether to consider the pooled variance estimate or separate variance estimate for the specified contrasts. The analyses were performed on the IBM 360 computer using the SPSS ONEWAY Package (Nie et al. 1970).

52. Standard statistical calculations (e.g., means, standard errors, etc.) were also performed with the aid of the IBM 360 computer. Graphical presentations were facilitated by means of Tectronix plotting software in conjunction with the IBM 360 computer.

PART V: RESULTS

Effect of Disposal of Dredged Material on Pelagic Flora and Fauna

53. There are no specific published studies concerning either the spatial or temporal distributions of flora and fauna within the Lake Erie nearshore waters off Ashtabula, Ohio. The following information, therefore, is presented to characterize the immediate area where dredged material disposal was evaluated in relation to effects upon the biological communities. The first regular sampling that involved the Reference Sites, described below, was in July 1975 and the last in July 1976, completing an annual cycle. Sampling during the winter months was not possible because of ice and/or high winds. A complete listing of the phytoplankton and zooplankton species encountered during this project in the nearshore waters (Lake Erie) off Ashtabula, Ohio, can be found in Appendix A2.

Phytoplankton

54. A major peak or observed maximum in phytoplankton numbers was observed at the Control Sites in the spring (Figure A11) during which counts reached almost 10,000 cells/mℓ. Another peak, of approximately half the above numbers, was seen in the fall. Between the spring and fall maximums, which are typical for the Central Basin as well as the whole of Lake Erie (Munawar and Burns 1976, GLL 1976a), there was a minor increase in cell numbers during midsummer (late July). The larger confidence interval associated with this observed mean (Figure A11), alone caused this to be questionable. However, it did coincide with chlorophyll a values. Total phytoplankton numbers ranged from a low of 1,698 cells/mℓ in late August to a maximum of 11,028 cells/mℓ in mid-May. The spring peak in phytoplankton was associated with the maximum in primary productivity that was observed in the area (Figure A11). The chlorophyll a concentrations, although not the maximum noted, also showed a peak during this interval. The maximum in pigments sampled occurred during the smaller fall phytoplankton peak. Nothing could be said concerning the primary productivity trend during this period because no

sampling was included to estimate photosynthesis. An interesting observation was that a small increase in chlorophyll a (Figure A11) was seen in late July, when the statistically questionable phytoplankton increase described above was observed. The smaller maxima of the primary productivity peaks (Figure A11) also was seen during this period, indicating that the cell number increase was not an artifact of sampling. Chlorophyll a concentrations ranged from 1.68 mg/m^3 in early June to 15.54 mg/m^3 in October 1975; while photosynthesis displayed a minimum of 1.2 mg $C/m^3/hr$ in early June and a maximum of 43.5 mg carbon per cubic meter per hour in mid-May. It should be noted that no primary productivity measurements were made during October 1975 when the chlorophyll a peak was observed.

55. Phytoplankton group compositions (Figure A11) illustrated that the peak in total numbers (May 1976) was characterized by high numbers of both the flagellates and the Bacillariophyceae (diatom) group. These two components of the floral community reached their maximum numbers simultaneously with maximums observed for primary productivity in this area. The other major peak for total phytoplankton numbers (October 1975) was attributed to major increases in the Chlorophyta (greens) and the Cryptophyta. These two groups peaked at the same time that maximums in pigment concentrations (Figure A11) were observed in this area. The Chlorophyta also reached large numbers in late July, a period of high primary production and somewhat higher chlorophyll concentrations. The Chlorophyta along with periodic increases in the Cryptophyta, represented better than 50% of the floral community from the smaller midsummer peak (Figure A11) through the last sampling period in 1975 (late fall). The major peak for the Chrysophyceae took place in early June (Figure A11), the period of lowest photosynthesis and pigment concentrations for the entire study period. The Cyanophyta (blue-greens) maximum, exclusive of the PW8 and PW9 collections, occurred in the late spring and early summer with another small increase in October. The Pyrrophyta (dinoflagellates) were never a dominant group in this area during the periods of sampling.

Zooplankton

56. The crustacean zooplankton (Figure A12) reached their maximum numbers in early June. The values observed per collection period were significantly different from one another at the 0.05 level. The temporal variation illustrated that this pelagic component only had one annual maximum for the area. This progressive spring increase in numbers followed very closely with the maximum cell numbers observed for the phytoplankton (Figure A11). The peak in zooplankton numbers lagged by approximately 20 days behind the floral trends, which was expected (Hutchinson 1967). This peak in zooplankton (111.3 organisms/ℓ) was followed by a general decline in the populations reaching a minimum of 13.9 organisms/ℓ in October. In considering the adult component of the crustacean zooplankton community, the Cyclopoida and Cladocera dominated throughout the study duration (Figure A12). The peak zooplankton numbers were comprised of > 60% cyclopoids. This group made up the largest component in numbers for the entire spring and much of the late fall. The Cladocera, on the other hand, reached their maximum numbers during the summer and extended into September. Early July was the only period of the entire investigation when the calanoids showed any major increase in numbers.

Sampling in 1975

57. Basin and site location. As previously indicated, several initial surveys by the GLL were made in the waters near Ashtabula in order to determine the experimental design and site location of the eventual Reference and Disposal Sites. The first regular pelagic sampling intervals consisted of two predisposal monitorings on 9-11 July and 30-31 July 1975. The intention was to characterize the nature of similarities between the Reference and Disposal Sites and to define initial conditions of both prior to the disposal event.

58. Predisposal sampling. The averaged results of the 9-11 July 1975 sampling for phytoplankton composition and pigments at 10 of the 11 sites initially selected and primary productivity at the two Reference (PW1 and PW2) and one Experimental Site (PW5) are illustrated in Figure A13. The phytoplankton and surface chlorophyll observations indicated a

relatively homogeneous water mass in the area during this sampling interval. (While these raw data were not homogeneous or normally distributed; however, after square root transformation all the data were homogeneous as defined by Bartlett's test.). The primary productivity records showed no real difference for the 1 m samples but indicated a slight decrease in primary production at PW2 for the 5 m depth. The chlorophyll a concentrations were similar in the immediate study area but did show higher levels at the inshore stations. The zooplankton samples for this time period were not preserved properly in the field, causing decay of the organisms. The final counts, therefore, were not reliable and, consequently, are not presented here.

59. The results for the 30-31 July 1975 predisposal sampling for phytoplankton, chlorophyll a concentrations, primary productivity (Figure A14), and zooplankton composition (Figure A15) illustrated a pattern that generally was typical for this area throughout most of the study duration. The influence of the River outflow and the nearshore currents appeared to have an effect on Stations PW8 and PW9, and to a lesser extent on PW10, which were located within the influence of these two factors (Figure A8). The phytoplankton composition at PW8 and PW9 indicated a much higher level of Chlorophyta than the other sites. The collections from PW2, which was closer to shore than the other reference station (PW1), showed a similar pattern for Chlorophyta. In addition, PW2 samples appeared to be unique for this period because they included the only major concentration of the Bacillariophyceae. However, when the results for total numbers and group compositions from Stations PW8, PW9, and PW10 were compared to those for PW1 through PW7 and PW11, they did not statistically differ ($P < 0.95$) except for the Cyanophyta ($P > 0.95$). The results from the 1-m primary productivity collection (Figure A14) indicated a similar pattern of higher levels nearer the shore (PW8, PW9, and PW10). The surface chlorophyll data illustrated that there was a larger biomass at the Reference Site (PW1 and PW2) as well as in the Disposal Sites (PW5 and PW6) that were closer to shore. The bottom chlorophyll concentrations, on the other hand, displayed a statistically homogeneous pattern similar to the phytoplankton compositions and primary

productivity. The crustacean zooplankton (Figure A15) indicated that nearshore influences may have been acting on Stations PW8 and PW9 because of increased numbers of calanoids. The remainder of the stations were relatively similar in composition.

60. Disposal operation sampling. The disposal of dredged material commenced on 4 August 1975 and continued through 14 August 1975. Just prior to the initiation of disposal, pigment concentrations were measured at one of the Reference Stations (PW1) and one of the Disposal Sites (PW3) to characterize biological conditions. As can be seen by Figure A16 and an ANOVA test, there was a significant difference between the two sites in terms of chlorophyll levels at the 1-m collection depth. This was probably a function of patchiness that has been observed elsewhere in Lake Erie (Great Lakes Laboratory 1976a).

61. During the operation, chlorophyll a was also chosen as an indicator of any immediate effects on the phytoplankton community. This parameter was measured at increasing intervals down-current from both disposal sites (PW3 and PW5). The results (Figure A17) indicated that over the period of 1 hr from deposition there appeared to be no change in pigments at the 1 m depth, 50 m away from the disposal site. The increase in concentration with time (60 min) at 100 m away from PW5 was almost double the initial measure for that distance. This increase could have been the result of stimulation in photosynthesis from released nutrients. The change in pigment concentrations was somewhat more evident with depth as the samples were taken further away from the disposal site. Lower chlorophyll concentrations at the 15 m depth were observed at 150 m distance from PW3 and at the 14 m depth, 300 m away from PW5. It should be noted that the lack of replicates made it difficult to subject these data to vigorous statistical analyses.

62. On the last day of disposal (14 August), samples for phytoplankton and zooplankton were taken at the 2 reference and 2 disposal dump sites as well as samples for chlorophyll a at both surface and bottom waters for all 11 water-quality stations. The results indicated that there was little difference between the reference and disposal for

phytoplankton (Figure A18). The PW3 collection did display a major increase in the Bacillariophyceae and the Cyanophyta. The change at PW5 was not as dramatic. The surface chlorophyll did show a slight increase but not statistically significant ($P < 0.95$) (Figure A18). While the bottom chlorophyll values appeared to show that the two Disposal Site results were lower than those from the Reference, the values were extremely variable between replicates (as indicated by the confidence intervals) and the differences were not statistically significant ($P < 0.95$). The zooplankton numbers and group composition (Figure A19) did not show any statistical difference between PW3 and PW5 and the other stations. PW3 results did separate from the others on both the X-Y axes and the X-Z axes when principal components analysis was performed on the raw data. The reason for this was that PW3 supported fewer numbers of cyclopoids than PW1 and fewer calanoids than either reference station. Furthermore, there was a slight increase in the cladocera compared to the reference stations. However, similar differences between zooplankton results have been noted in the Lake Erie Eastern Basin in areas not impacted by disposal (GLL 1976a). Therefore, the differences noted at the Ashtabula site are questionable.

63. Postdisposal sampling. Five days after disposal was completed (19-20 August 1975) all pelagic biological variables were measured at all 11 stations of the study area. The phytoplankton showed no real changes between Reference and Disposal Sites (Figure A20), either for total number or group composition. Slight increases were observed, perhaps due to the nearshore effects (PW8 and PW9) already discussed. Chlorophyll a and primary productivity data for the surface waters (Figure A20) showed the same nearshore increases. With the exception of slightly higher primary productivity at Station PW3, there was little difference between the Reference and Disposal Sites. While the bottom chlorophyll concentrations, however, did indicate a slight increase at the Disposal Sites (Figure A20) similar to the nearshore stations, this was not statistically significant. Total numbers of crustacean zooplankton (Figure A21) did not change substantially between stations during this time interval but the stations did differentiate to a small

degree according to group compositions. Results from PW8 and PW9 showed slightly lower numbers of calanoids as did PW3 collections. While Station PW5 data, on the other hand, showed the highest number for this group and while the Reference Site samplings were characterized by intermediate numbers, the overall difference between stations was not atypical for Lake Erie.

64. Community ordination, using the principal component technique, was performed on all the phytoplankton and zooplankton species populations for the remainder of the sampling periods. In general, these analyses showed that there was as much, and in most cases, more separation between the stations nearer shore and those further away than between the Reference and Disposal stations. Therefore, the remainder of the results concerning the pelagic flora and fauna will be presented in general terms emphasizing only any deviations from the above pattern.

65. Samples taken 30 days after disposal for phytoplankton and chlorophyll a concentrations (Figure A22) and zooplankton (Figure A23) indicated that conditions in the pelagic environment were stabilized completely and patterns were similar to those observed prior to disposal of dredged material. As indicated previously, the Chlorophyta were becoming the dominant group, especially at the nearshore stations. The pigment concentrations were beginning to peak and also showed higher levels nearer shore. No differences were observed between the Reference and Disposal Sites. The crustacean zooplankton also displayed patterns more related to proximity to shore than to effects from disposal. Stations PW3 and PW5 results did display lower total numbers than those from the reference (PW1 and PW2), but the group composition ratios were all very similar, indicating no real differences.

66. Approximately 60 days after disposal, sampling again was conducted on all pelagic sites. Phytoplankton numbers had reached their maximum for the fall (Figure A24) as had the pigment levels. No difference existed between collections from Reference and Disposal Sites, and the phytoplankton counts still showed greater numbers at the nearshore stations. The zooplankton (Figure A23) again were very low in number as observed in the previous sampling period. Also in agreement

with the previous period was the observation that the zooplankton appeared to be lower in total number at the two Disposal Sites as compared with the Reference Sites. The taxonomic ratios, however, remained similar.

67. The last major sampling effort in 1975 was conducted 90 days after disposal, again on all 11 stations. Most collections showed similar group composition for phytoplankton (Figure A25) among stations but several displayed higher levels for the bluegreens (Cyanophyta). The Reference and Disposal Sites again were very similar as indicated by community ordination. Furthermore, no major differences were apparent from the observed pigment concentrations (Figure A25). Primary productivity was also measured during this period at 1 and 2 m below the surface. Again, no major differences between data from Reference and Disposal Sites were observed. The same was true for the zooplankton observations (Figure A23).

Sampling in 1976

68. With the start of the 1976 phase of the dredged material disposal project, sampling was discontinued due to budgetary limitations at all stations but the two Reference Sites, PW1 and PW2, and the two Disposal Sites, PW3 and PW5. A new station, NDS (Figure A8), was included in the sampling plan for 1976. As described previously, this station was the Pelagic Site for the new series of disposal events that would be monitored in 1976.

69. Predisposal sampling. The first sampling (predisposal) of these sites was conducted on 21 April, both as a continuation of the long-term studies related to the 1975 disposal events as well as part of the predisposal monitoring for 1976. The phytoplankton observations (Figure A26) indicated that PW1, PW2, PW5, and NDS were very similar in both total numbers and group composition. Pigment levels and primary productivity rates (Figure A26) indicated similar trends. The group composition for phytoplankton at Station PW3, however, did show some differences. There were fewer Chlorophyta and many more Crytophyta than at any of the other sites. Neither the primary productivity nor chlorophyll observations, however, supported the above. The zooplankton numbers (Figure A27) were very similar at all sites and were composed

almost exclusively of cyclopoids.

70. By the 15-16 May sampling, which was the last predisposal monitoring before the 1976 disposal of dredged material, phytoplankton had passed their peak numbers but reached the observed maximum for chlorophyll and primary productivity (Figure A28). Bacillariophyceae (diatoms) and flagellates almost totally dominated the community. Community ordination indicated a heterogeneous water mass in the area although the group composition did not show any real differences between stations. The reason for these differences probably was related to individual diatom species. For example, *Stephanodiscus* sp. showed decreased numbers at PW3 compared to results from other stations while, in turn, *Fragilaria* sp. was much higher at PW3 than at the other sites. This trend was related to patchiness of individual populations (Hutchinson 1967, Wetzel 1975) rather than any influence from the 1975 disposal event. Surface chlorophyll *a* measurements were almost identical at all sites (Figure A28) while primary productivity indicated higher means for samples from PW3 and PW5 than for collections from the Reference Sites. These differences, however, were non-significant when the confidence intervals were considered. The crustacean zooplankton showed no real differences between sites other than just total number (Figure A27). Taxonomic composition ratios were very similar at all stations.

71. Postdisposal sampling. The remaining two pelagic postdisposal samplings, which are described below, were designed to characterize the changes following the 1975 disposal operation (comparisons of results from PW1 and PW2 with those from PW3 and PW5) and also describe any short-term effects of the 1976 disposal events (comparison of data from PW1 and PW2 with those from NDS). The results from the 10-11 June sampling, which was 5 days after the 1976 disposal event, showed no differences between any of the 1975 stations for phytoplankton numbers, chlorophyll *a* concentrations, or primary productivity (Figure A29). The comparison of the Reference Site data with those from NDS indicated that there were slightly lower levels of Chlorophyta at the NDS site and also that the rates of primary productivity from 1 and 3 m were both somewhat

lower at the NDS station. However, the latter was not statistically significant. The group composition ratios for the zooplankton (Figure A27) were not very different between locations except for an increase in cyclopoids at PW1. The total numbers were higher at both PW3 and NDS. However, numbers at PW5 were within the range in the Reference Site. A possible reason for the same trend observed at PW3 was related to the fact that this site was down-current from NDS and probably in the same water mass (Danek et al. 1976).

71. The results from the final sampling, 30 days after the 1976 disposal (7-8 July 1976), showed no major differences in any of the variables measured (Figures A27 and A30). The conditions measured at the NDS site appeared to have stabilized from the 1976 disposal. No additional long-term effects were observed at PW3 or PW5 from the 1975 disposal.

Bioassays

72. The phytoplankton numbers and group composition as well as the crustacean zooplankton appeared to recover rather rapidly from any pelagic effects from the disposal of dredged material in the open-lake environment. This also was not the case for chlorophyll a and primary productivity. However, these parameters were measured in the study sites and given the speed and direction of the currents, may have been more of a function of up-current conditions rather than as a response to the disposal activities. Therefore, the following experiment was designed to simulate what response in the primary productivity may occur in the plume caused by disposal. A series of bioassays were performed using natural populations subjected to various levels of elutriate additions, as described in Part IV.

73. The bioassays were run at four different times between 15 May and 14 September 1976 and used natural populations dominated by different species for each of the four experimental series. The 15 May bioassay was run on a phytoplankton community dominated by diatoms and flagellates. The 11 June experiments were performed on samples containing Chrysophyceae in large numbers along with increased abundances of the Cyanophyta. The 17 July and 14 September bioassays were performed during dominance of the floral community by the Chlorophyta.

74. The average values of the four bioassays indicated that elutriate additions had a significant effect on primary productivity rates for each experiment (Table A5). Primary productivity represented by counts per minute (cpm) of fixed ^{14}C was affected significantly ($P < 0.001$) from the first experimental procedure (Figure A31). Inhibition of photosynthesis occurred from additions of 10.0, 15.0, and 25.0 mℓ of the elutriate. According to Figure A31, these ranges appeared to stimulate heterotrophic activity (dark bottles) and inhibit light bottle uptake of ^{14}C. The 15.0-mℓ additions, although significantly lower than the controls, did not induce the same pattern as the 10.0- and 25.0-mℓ additions. This possible was related more to experimental error than to natural phenomena. There also were slight inhibitions seen from the 1.0-mℓ additions, but these were not significantly different from the control due to the large standard deviations.

75. The results from the second series of bioassays (11 June) displayed a significant difference between the control and elutriate addition ($P < 0.01$). Again, inhibition (not significant) was seen at the lowest elutriate addition (Table A5, Figure A32). The results from the remainder of the treatments showed stimulation for gross photosynthesis, but as before, much of this was represented by heterotrophic activity. The mean cpm (corrected for dark bottle counts) for the 1.0-mℓ and 5.0-mℓ elutriate additions (Table A5) indicated a slight stimulation over the control, although not significantly different. There was a significant inhibition to ^{14}C fixation seen for the 15.0-mℓ and 25.0-mℓ additions.

76. The observations from the third bioassay experiment (27 July) illustrated a significant difference ($P < 0.001$) between the control and experimentals. The additions, again, inhibited primary productivity (Figure A33) while a significant inhibition was seen starting at the 1.0-mℓ quantity of addition, much lower levels than seen previously. As in the two bioassays described above, the 15.0- and 25.0-mℓ elutriate additions appreciably inhibited photosynthesis ($P < 0.001$). In addition, heterotrophic activity was not as great as observed from the previous experiments.

77. The final series (14 September) yielded findings that also showed

a significant effect on photosynthesis ($P < 0.001$). A marked stimulation occurred ($P < 0.04$) from the 0.1-mℓ addition (Table A5). This was followed by no significant difference between the controls and 1.0-, 5.0-, and 10.0-mℓ additions of the elutriate concentration. As seen in the results from the three previous bioassays, significant inhibition (Figure A34, Table A5) in ^{14}C uptake occurred from 15.0- and 25.0-mℓ additions. The heterotrophic activity again was minimal.

78. It was quite interesting to note that not only did inhibition of photosynthesis occur from higher concentrations of elutriate, but also, under certain conditions, the addition of elutriate stimulated heterotrophic (bacterial) activity. As Figures A31-A34 illustrated, the dark bottle activity, in relation to the light bottle activity, was much greater in the first two bioassays than in the last two. This may be explained by the fact that the elutriate mixture was not filtered prior to elutriate addition during the first two bioassays. As a result, some precipitate was observed in the incubation bottles. Consequently, a suitable substrate (particles) may have been provided for bacterial colonization and growth (Paerl 1974). If this was the case, the possibility of heterotrophic uptake could explain the increases observed (Figures A31 and A32). The last two bioassays were performed with filtered elutriate additions, and no major dark bottle uptake was noted. This failure to filter the first two series of elutriate additions provided additional valuable information, suggesting that the impact of dredged material deposition to the pelagic water column may reflect increases in bacterial activity.

Effect of Disposal of Dredged Material on the Benthic Fauna

Coastal environment

79. No previously published studies were found concerning the spatial and temporal variations of the benthic fauna within the coastal area of Lake Erie in the vicinity of Ashtabula, Ohio. Quantitative sampling for benthic organisms as part of the Initial Survey phase of this open-water disposal project in the nearshore waters of Ashtabula appeared to show

a heterogeneous bottom community (Table A1). However, when community ordination was performed, as presented in a later section, there were more similarities among the benthic data than differences. The complexity of long-shore currents in the study area as well as the outlet of the Ashtabula River and previous disposal of shale removed from the harbor contributed to the high variability of sediment types. Current velocities were believed to be an important factor contributing to the amount of scour, resuspension, and sedimentation. The types of bottom material in this area ranged from shale to a fine sand to a silty mud (Danek et al. 1976). The variability and heterogeneity of these substrates were readily observable in the area designated for investigation. Thus, while similar types of substrate existed in areas separated from one another by various distances, it was not possible to establish identical sampling stations between different locations since the same physical conditions did not exist other than in severely restricted areas. Since sediment type strongly influences the quality and quantity of the benthos (Odum 1971), the benthic fauna also were heterogeneous.

80. Sample collections. The first sampling of the bottom macrofauna was conducted in July 1975 and the last in July 1976. A total of eight samplings were undertaken between these dates which enabled characterization of the temporal and spatial variability in the bottom community. However, no collections were made between December 1975 and April 1976 because of winter conditions. A complete listing of the benthic invertebrates observed during this project in the nearshore waters (Lake Erie) of Ashtabula, Ohio, can be found in Appendix A2.

81. Estimation of the mean number of species, mean number of organisms per square meter, and group composition for two of the reference stations (C1 and C3) is presented in Figure A35 for the entire study duration. These illustrations not only demonstrate the temporal variability in different major groups but also show the spatial variability noted previously. Collections at Station C1 differed from those at C3, primarily because of the large numbers of spheriids observed at C1. The sphaerids, primarily *Pisidium* sp., appeared to displace the oligochaetes in total numbers. The remainder of the groups at each site were similar in number. Total number of species

and individuals were both similar between the two sites over the majority of the study duration. C1 showed a slightly higher level for both variables in the late spring of 1976. Examination of the temporal variation, for both sites (Figure A35), showed that the maximum number of organisms occurred in late summer and early spring. The number of species appeared to follow patterns similar to the total number of organisms in most instances.

82. The major groups comprising the benthic community showed variations in their maximums throughout the year. As expected with Lake Erie benthic communities (Great Lakes Laboratory 1976a), the Oligochaeta were the most abundant group present and peaked in midsummer (30 July). The chironomids, consisting almost totally of Procladius sp. and Chironomus sp. reached their observed peak in abundance in the early spring (20 April - 15 May). The plots (Figure A35) indicated, however, that this group may have actually reached maximum numbers in the winter when no sampling was performed. This seemed to be the case since the period of maximum chironomid number appeared to be on the decline when sampling resumed in the spring. The chironomids, over the study duration, displayed the second highest number of organisms at C3.

83. At Station C1 with the exception of the oligochaetes, the sphaerids, as already described, showed the highest accumulations. They reached their maximum numbers in early fall (14 September) at Station C1 (Figure A35) but did not show a peak at Station C3 until 15 May 1976. The nematodes also exhibited a maximum number for this sampling period at C3 but were fairly uniform in number throughout the entire year at C1.

84. The Isopoda showed a similar trend at both sites, reaching maximum numbers in midsummer (8 July). This group was represented totally by Asellus sp. (in most cases, Asellus racovitzai racovitzai). The Gastropoda, comprised of Valvata sp. and Amnicola spp., were relatively stable in number throughout the year with changes seen only at the species rather than the order level. Station C3 (Figure A35), unlike C1, had an occasional occurrence of the Hirudinea group in the late fall and early spring. As with the chironomids, this group appeared to reach maximum numbers in the winter.

85. Tables A6 and A7 contrasted the different species compositions at the two Reference Sites (C1 and C3). From these tables, it was concluded that the majority of the oligochaetes were comprised of immature fauna. The dominant adult species were Aulodrilus pluriseta, Peloscolex multisetosus, Limnodrilus hoffmeisteri, and Aulodrilus americanus. Of these four numerically dominant species, collections from C1 showed higher numbers only for P. multisetosus. Station C3, on the other hand, displayed much higher total numbers throughout the year for the other three major oligochaete species.

86. Tables A6 and A7 also showed that the nematode group was almost totally comprised of Dorylaimus sp. Again, Station C3 supported much higher numbers than C1. In general, it appeared that because of the domination of the sphaerid group at the C1 Reference Site (Figure A35 and Table A6), many of the other species and groups were suppressed in relative numbers although not in diversity as indicated by similar trends in species number between C1 and C3. These biological differences were believed to be related to the variations in bottom substrates between the two areas (Great Lakes Laboratory 1977).

87. Vertical distribution of the different major groups over the duration of this study showed some interesting trends (Figure A36). The majority of organisms were found in the first 5 cm of the sediment (section No. 1) which included the more mobile forms, the chironomids and the isopods. The oligochaetes were relatively evenly distributed throughout the sediment with no section ever showing much less than 50% composition. As found in many marine situations (Smith and Howard 1972, Oliver 1973), the larger organisms (comprising more biomass) were found deeper in the sediments. These included the molluscs (sphaerids and gastropods) that exhibited a mean dry weight of 2.12 mg per individual based upon analyses of more than 650 organisms (Great Lakes Laboratory 1976b). In contrast, the oligochaetes weighed a mean of 0.20 mg per individual for dry weight measures of over 6000 individuals. These molluscs showed relative maximum densities in the second and third sections (> 5 cm deep) of the sediment. The lowest numbers of organisms per square meter were observed in the

second (5-20 cm) and third (> 20 cm) sections during the early to midsummer periods. This may have been related to depletion of oxygen and food sources in deeper sediment layers during this interval. The only occurrence of ostracods within the macrobenthos was observed in the third section in late spring (15 May). When the isopods reached peak numbers (10 June - 18 July) they distributed themselves throughout the sediment, perhaps as a result of competition.

88. 1975 predisposal sampling. Prior to the initiation of the 1975 disposal monitoring, a series of collections were made in both the Ashtabula River and Harbor in an attempt to evaluate the community composition of the dredged material that would eventually be disposed in the open-water lake environment. Table A8 shows the results of these collections. The River habitat supported a much greater number of organisms that included a numerical domination by the oligochaetes *Limnodrilus hoffmeisteri*, *L. cervix*, and *L. maumeensis*. The Harbor sites also were dominated by *L. hoffmeisteri* and *L. maumeensis* but also exhibited greater numbers of *Potamothrix vejdovskyi*, *Peloscolex ferox*, and the chironomid *Chironomus* sp. In addition, the River habitat supported several species of *Sphaerium*, which were absent in the Harbor. The Harbor sediment, on the other hand, contained *Pisidium* in much greater abundance. The dominant chironomid in the River was *Procladius* sp., contrasted to *Chironomus* sp. in the Harbor. The isopods were absent from the Harbor.

89. The initial major sampling effort was conducted on 30-31 July to establish initial conditions of the benthic sampling sites prior to the long-term monitoring of disposal effects. Four reference sites (C1-C4) and twelve disposal sites (D1-D12) were sampled and evaluated for benthic macroinvertebrate fauna. Community ordination (Figure A37) of the logarithmic data for the species observed at each site indicated that apparent homogeneity existed between all stations except for D5. This contrasted with the heterogeneous distribution. The gastropods and isopods, however, appeared to be slightly different between the Reference Sites and the Center Disposal Sites (Figure A38). Not apparent in Figure A38, however, which was accounted for by the principal components (community ordination) (Figure A37), was the species similarities between sites.

Consequently, it was assumed that all stations except D5 were similar prior to the initiation of disposal on 4 August 1975 when dredged River material was disposed on Site D2 and Harbor materials on the D8 Site. However, it should be pointed out that the high oligochaete values may be over dominating the results of the principal components analyses.

90. Postdisposal sampling. Five days after the completion of disposal (19 August 1975), the first postdisposal sampling was conducted. Additional collections were made 30 days after (14 September 1975), 90 days after (15-16 November 1975), the following spring (21 April 1976), and approximately 1 year after the 1975 disposal (8 July 1976). For the long-term evaluations, the results observed on the Reference Stations C1 and C3 and the Disposal Stations D2 and D8, the stations directly covered by disposal materials, were emphasized more than those from the other collection stations. Figure A39 showed that definite changes in both species number and number of total organisms per square meter occurred following the disposal events. Both Disposal Sites increased in total numbers of organisms 5 days after disposal and showed corresponding decreases in total species present compared to the Reference Sites. Although the absolute number of either species or total number of organisms did not agree between the Reference and Disposal Sites even prior to disposal, the trends in the numbers of organisms and species at the Disposal Sites in contrast with the Reference Sites were of a similar nature and were assumed to be more important than the absolute numbers. The general changes in species number and number of organisms per square meter for the two Reference Sites remained similar throughout the entire sampling duration (Figure A39). The increase in number of organisms observed 5 days after disposal continued at Station D2 30 days after disposal while the number of species leveled off. The total number of organisms increased while species number began to level off. Collections from Station D8 showed a somewhat different pattern. After the initial increase (5 days after disposal), the number of organisms at D8 dropped well below that at Reference Sites and D2 but species number remained stable and near levels before the disposal event. The 90-day postdisposal sampling indicated that an influx of species had

occurred at the D2 site and that total number of organisms per square meter was still high but declining. The species number at D8 remained stable, not showing the high influx illustrated by D2 samples while the total number of organisms increased to levels observed before disposal.

91. The results from the remaining two 1976 samplings to evaluate the long-term effects of dredged material disposal (Figure A39) displayed that at both Disposal Sites the species number, although not at Reference Site levels, showed trends similar to the Reference. The number of organisms at the Disposal as well as the Reference Sites declined. There was a slight increase in the number of species noted on 21 April, followed by a decline.

92. Although Stations C1, C3, D2, and D8 were the focal points during the long-term examination to ascertain the impacts of disposal on the benthic fauna, the remainder of the Reference and Experimental stations were sampled and analyzed to major taxonomic group (see Part IV). These data for the sampling events for 15 days before disposal and 5 days, 30 days, and 90 days after disposal were evaluated with the use of discriminant analysis on the group compositions. This statistical procedure facilitated several important determinations. First, this analysis was used to determine similarities and differences among these stations over the observation period. Secondly, it was possible by this process to identify faunal groups that contributed the most to discrimination between the Reference and Disposal Sites. The discriminant analysis procedure showed that the benthos collected from the three sites used as standards (C1, C3, D2, and D8) were significantly ($P > 0.95$) different from each other during the three postdisposal samplings. Therefore, the results from these sites were used to evaluate the relative changes with time for the other experimental and reference stations. It should be noted, however, that the analysis was less successful in ascertaining differences between the three sites used as standards during the predisposal sampling. Five of the eight replicate benthos samples from the Reference Site and two of the four replicates at each of the two Experimental (Disposal) Sites were not classified with a significant degree of confidence ($P > 0.95$) within their respective groups. Therefore, the

conclusions drawn from the predisposal sampling are less valid than those from the other three sampling dates. Through the use of discriminant analysis, the data from each sampling period were classified in one of the following four cases: Case 1, those stations whose communities were similar to the Reference Site (C1, C3) communities; Case 2, those stations whose communities were significantly ($P > 0.95$) similar to the Harbor Disposal Site (D2); Case 3, those stations whose communities were significantly similar to those at the River Disposal Site (D8); and lastly, Case 4, those stations whose communities were not significantly similar to either those at the Reference or Disposal stations (Table A9). The communities at stations classified in Case 4 had characteristics of more than one of the four sites that had been used as standards (C1, C3, D2, and D8).

93. Discriminant analysis of the data from predisposal sampling produced the following groupings: Stations C2, C4, D5, and D6 benthos were classified as Case 1 (i.e. most similar to Reference Sites C1 and C3). Station D12 organisms, on the other hand, were placed in Case 2, while those from D7 and D11 were classified as Case 3. The benthos of Stations D1, D3, D4, D9, and D10 were unlike the standards. Therefore, they were grouped in Case 4. The difference between benthos gathered during each of the four sampling dates was determined by examining the group composition from the Reference (C1 and C3) and the two Disposal Sites (D2 and D8). The faunal groups that best discriminated between the Reference and Disposal Sites at 15 days before disposal were isopods, gastropods, chironomids, and sphaerids (Table A10).

94. Analysis of the data from 5 days after disposal indicated that most, but not all, the stations were impacted by disposal. Stations C2, C4, and D6 benthos continued to be most similar to the Reference stations. In addition, D9 and D12 also were classified as Case 1. Benthos from Station D1 were classified as Case 2, while D5 and D10 bottom organisms were grouped in Case 3. The benthos at the remaining stations (D3, D4, D7, and D11) were different from Cases 1, 2, and 3 and, therefore, placed in Group 4 (Table A9). The most important benthic family groups identified as causing the shift in the affiliation

of many of the stations were oligochaetes, isopods, chironomids, nematods, and gastropods (Table A10).

95. The 30-day postdisposal sampling data displayed some important differences from the 5-day postdisposal data. The important family groups were quite similar as the oligochaetes were the most important discriminating variable with the nematodes and gastropods contributing less discriminating power. Stations C2, C4, D6, D9, and D12 benthos were still classified as Case 1, while the bottom communities at Stations D5, D7, and D10 also were similar to the latter. At the 5-day postdisposal sampling, the benthos from Stations D5 and D10 had been significantly similar, while those from D7 were somewhat similar to those at the River Disposal Site (D8). The change at the 30-day postdisposal sampling was attributed primarily to the mean numbers of nematods ($199/m^2$) and gastropods ($799/m^2$) for D5, D7, and D10 as compared to the Reference and Disposal stations (Table A10). In addition, the mean number of oligochaetes at these stations ($18,049/m^2$) was more similar to those at the Reference stations than to those at either D2 or D8. The second change from previous conditions was noted at Stations D1 and D11. The data from 30-day postdisposal sampling were classified in Case 3 due mainly to the very small mean number of organisms per square meter of nematodes (32 per square meter) and gastropods (8 per square meter) and relatively small numbers of oligochaetes per square meter (12,635 per square meter) as compared to the standards (Table A10). Station D4 benthos were classified as significantly similar to the River Disposal Site (D2) benthos due to the large number of oligochaetes per square meter (27,600 per square meter) and the relatively small number of nematodes and gastropods (56 organisms per square meter for both). Station D3 benthos remained unchanged from 5-day postdiposal and was the only station that was not grouped within the first three cases.

96. Collections of the benthic macrofauna 90 days following disposal from all sites indicated that the community structure at the majority of stations was similar to those at the Reference Sites. Six benthic groups were chosen as providing discriminating power. They were, in order of importance: gastropods, chironomids, oligochaetes, sphaerids, isopods, and nematodes. Many of the communities at stations that were similar to those at Reference Sites at 30-day postdisposal continued to

look similar to those at C1 and C3. These stations included C2, C4, D6, D9, D10, and D12. In addition, Stations D4 and D11 benthos were also classified in this group. Station D4 results were apparently placed in this group because the numbers per square meter of oligochaetes (8370), sphaerids (917), and chironomids (917) were quite similar to the mean numbers per square meter for the same organisms at the Reference Sites (Table A10). Station D11 data were classified in the same group for slightly different reasons. The numbers per square meter for oligochaetes (10,317), isopods (393), gastropods (524), and nematodes (374) were similar to the Reference Sites (Table A10). Two communities showed change in the opposite direction. Station D5 and D7 benthos had been classified as similar to those at the Reference Sites at the 30-day postdisposal sampling (Case 1). However, at 90-day postdisposal, they were classified as significantly similar to the Harbor Disposal Site (Case 3) as were those at Station D1. Station D5 benthos changed from Case 1 to Case 4 since numbers per square meter for four of the six benthic groups, including oligochaetes (12,976), gastropods (75), sphaerids (131), and nematodes (56), were similar to those found at Station D8. The benthic groups that accounted for Station D7's change were sphaerids (91 per square meter), nematodes (157 per square meter), and chironomids (258 per square meter) (Table A10). The only benthic community that was classified as Case 4 at 90-day postdisposal was that at Station D3, which was also in that category at 5- and 30-day postdisposal.

97. Samples from Disposal Station D2 possibly showed more than a 100% increase in number of organisms 30 days after disposal (Figure A39) while collections from Station D8 showed a 100% increase. Perhaps these conclusions are tempered by the large confidence intervals. The initial increase was ascribed to the addition of organisms within the dredged material. Examination of the group compositions over time led to this conclusion. After disposal, the increase in numbers at both sites was characterized by communities comprised of more than 98% oligochaetes (Figure A40) compared to 93% and 78% at D2 and D8, respectively, before disposal. The Reference Site communities ranged between

60% and 80% oligochaetes during this time interval. The situation 30 days after disposal had changed on D8 but still remained exclusively oligochaete dominated (99%) at D2. The D8 collections showed an increase in organisms belonging to the chironomids, sphaerids, gastropods, and isopods. The combination of an increase in groups other than the oligochaetes at D8 (Figure A40) together with the large decrease in total numbers of organisms per square meter (Figure A39) suggested recolonization was occurring on this site.

98. The communities on the two Disposal Sites 90 days after disposal (Figure A40) showed a decrease of sphaerids at D8 and the recolonization of chrionomids and sphaerids at D2. The percent composition of oligochaetes had increased again at D8 but showed levels at D2 comparable to those before disposal. With respect to the results from the remaining two sampling intervals (21 April and 8 July 1976), D2 collections showed a general increase in the number of groups comprising the community. The April and July 1976 collections at D8 showed no consistent pattern but did indicate trends comparable to the collections from the previous year prior to disposal (31 July 1975) for the 8 July 1976 sampling interval (Figure A40).

99. The use of principal components analysis served as a valuable means of determining the similarity and dissimilarity at the species level between the Reference and Disposal Sites as the communities changed over time. As previously mentioned, organisms at the Disposal Sites, D2 and D8, were almost exclusively oligochaetes which occurred in higher total number of organisms than at the references (Figure A41) 5 days after the disposal of dredged material. Figure A41 also illustrated that the two additional Disposal Sites, D3 and D9, were relatively similar in group composition to the Reference Sites. They both supported a greater diversity of organisms than either D2 or D8. If they were markedly affected by disposal, it was not readily apparent. The only group of organisms affected was the nematodes, which disappeared from D3. The separation between the two Reference Sites on the X-Y ordination axes (Figure A42) was quite wide and possibly accounted for by the big difference concerning the sphaerids and gastropods between

C1 and C3 (Figure A41). Three of the replicates for D8 and all the replicates for D2 were separated from the reference samples on the X-Y axes (Figure A42). The D8 replicates appeared to be more dissimilar than the D2 replicates. This separation could have indicated that the two sites received different species of oligochaetes from the dredged material since D2 received Harbor materials and D8 received River materials. Three species of Aulodrilus were present at D8 while Limnodrilus was represented in very low numbers (Table A11). The D2 community, however, was completely dominated by Limnodrilus spp. with very few Aulodrilus (one species) present (Table A12). Therefore, 5 days after disposal, the two center dump sites (D2 and D8) differed from the Reference Sites due to the increased number of species observed at the Disposal Sites and domination of the community by oligochaetes. The two Disposal Sites differed from one another possibly because of the source of material disposed on each.

100. The vertical distribution of organisms in the sediment 5 days after disposal displayed trends similar to those previously described (Figure A43). The samples from the Reference stations maintained their diversity throughout the sediment column. The Disposal Site collections, however, showed that almost all species, other than the oligochaetes, were either covered by the disposal material and eliminated or migrated out of the area. Furthermore, the Reference collections showed a decrease in oligochaete composition after the first section (top 5 cm of sediment) while not until the third section of D2 (10-20 cm below surface) did anything other than oligochaetes occur at the Disposal Sites.

101. As partially indicated by the 5-day postdisposal collections, D3 and D9, the Experimental Sites that were not in the center of the location where dredgings were released, appeared to recover (according to major group analysis) from any impact by 30 days after disposal (Figure A44). Collections at D8 indicated that this site had increased in diversity of community groups although much lower in the number of organisms than the references. A similarity between D8 and the references was illustrated by the lack of separation on the community

ordination axes (Figure A45). The D2 replicates, however, remained very distinct from the references and, as illustrated in Figure A44, still supported oligochaetes (> 99%) in great abundance. Although D8 and the reference stations appeared to be similar based upon ordination (Figure A45), the species present in some cases were different. Sphaerium sp. was absent from D8 (Table A11) while present at the Reference Sites (Tables A6 and A7). Another major difference between D8 and the references was that D8 supported only one Aulodrilus species while C1 and C3 collections showed several. Peloscolex ferox comprised 30% of this genus group on D8 while it was absent from C1 and C3. The results indicated that the D8 community, because of lower species and total organism numbers (Figure A39) was experiencing recolonization, which included the appearance of the chironomid group again, a taxa absent at Station D2 (Figure A44, Table A12).

102. By 90 days after disposal (16 November 1975) the benthos at Stations D3 and D9 continued to show a recovery from possible impacts (Figure A46). The chironomids returned in numbers similar to the Reference Sites. Sphaerid ratios were similar between C1 and D3 and C3 and D9. The gastropods again were noted in greater numbers at both D3 and D9 than at the references, a pattern also observed for the 30 July sampling interval prior to disposal (Figure A38). Stations D2 and D8 both showed a definite change compared to the 30-day postdisposal sampling interval (14 September 1975). The separation between replicates of both the Disposal and Reference Sites was much less (Figure A47). There were still some major differences, however, observed in the community compositions of the Disposal and Reference stations (Figure 46 and Tables A6, A7, A11, and A12). The Aulodrilus numbers increased at D8 and D2, while at the Reference Sites these species represented better than 30% of the oligochaetes. The chironomids finally recolonized the D2 site and increased at all sites, due to the initiation of their season of peak abundance in this area (Figure A35). The results of the vertical section analyses (Figure A48) indicated that the chironomids as well as many other groups had recolonized the Disposal Sites. The first core section of the disposal stations sites (D2 and D8) was the only

area of the sediment that supported diversity of organisms similar to those from the Reference stations. The deeper sections from the reference exhibited the presence of oligochaetes, chironomids, sphaerids, and gastropods, while the Disposal Site collections, other than the oligochaetes, only showed the presence of nematodes in any abundance beyond the first section (Figure A48). These results indicated that the organisms found on the Disposal Sites were believed to be recolonizing and had not distributed themselves vertically. The nematode group appeared to be the only taxa that inhabited the deeper layers of the sediment on the Disposal Sites.

103. The ordination axes (Figure A49) indicated that considerable separation had occurred between the Reference and Disposal Sites by the time collections were taken in the spring after disposal (21 April 1976). The group composition for the sites (Figure 50) showed that the chironomids were still abundant at all sites except D8. The nematodes peaked during this period of year (Figure A35) but represented less than 1% of the community composition on the Disposal Sites (D2 and D8). *Aulodrilus* spp. showed no further increase at the Disposal Sites (Tables A11 and A12) but still represented better than 18% of the Reference Site communities (Tables A6 and A7). *Limnodrilus* was represented by two species and comprised less than 2% of the community composition on the Reference Sites. On the Disposal Sites, however, this genus was represented by six species which comprised 5-10% of the community. The chironomids which had reappeared at the Disposal Sites 90 days after disposal appeared to decrease at these sites the following spring (Figure A50). This was more evident at the Disposal Areas than at the references. The collections at D8 indicated that chironomids were still in very low numbers at the Disposal Sites as were the isopods which had begun to show seasonal increases in the reference communities. The vertical distribution of major groups (Figure A51) indicated that the chironomids became established throughout the sediment column at D2 as did the sphaerids at both D2 and D8. The comparison of Reference and Disposal Site sections (Figure A51), however, indicated that there were still major differences existing between the communities.

104. Community ordination of the samples taken approximately one year after the 1975 disposal of dredged material showed that the Reference Sites (C1 and C3) and Disposal Site D2 were similar in community composition (Figure A52). The collections for D8 showed a different pattern. Of the four replicates taken, two seemed very similar to the collections for C1, C3, and D2. The other two, however, separated from the rest on the ordination axes (Figure A52). The two replicates of D8 that separated from the rest were characterized by very low species numbers represented almost totally by oligochaetes and very high total organism counts. The oligochaete composition at C1, C3, and two of the D8 replicates similar to the references was dominated by Aulodrilus spp. while the collections at D2 showed a dominance of Limnodrilus spp. The references differed from the disposal collections the most in exhibiting higher percentage numbers of sphaerids and isopods (Figure A53) and low percentage of amphipods which were more numerous in the deeper sections of D2 and D8 (Figure A54). The gastropods, which were not present in any great number on the Disposal or Reference Sites, did not distribute themselves vertically at the Disposal Sites as they did on the reference stations. As already noted, the amphipods concentrated in greater numbers on the Disposal Sites and also appeared in the deeper layers of the sediment.

105. General trends and patterns have been identified in the evaluation of long-term effects from open-water disposal of dredged material. Since the majority of organisms at all sites, both Reference and Disposal, were characterized by oligochaetes, it was felt that an examination of their species composition might provide additional information. Figure A55 presents the distribution of the oligochaetes for each station and each sampling interval. The immature tubificids both with and without hair setae were the dominant groups throughout the study duration at all sites. The Aulodrilus group exhibited very large numbers at both Reference Sites but never really showed high numbers at the Disposal Sites until one year later (8 July 1976) at D8. Limnodrilus spp., which were present at D2 prior to disposal, increased while Aulodrilus decreased at the disposal stations. Peloscolex spp. (except for P. ferox) was relatively abundant on the Reference

Sites, especially during the 21 April and 8 July 1976 sampling intervals. This group, which was low prior to disposal, decreased appreciably on the Disposal Sites. Potamothrix spp. also increased in numbers at the Disposal Sites.

106. The two groups that were referred to previously as dominating the Oligochaete group composition, the immature tubificids with and without hair setae, showed some interesting trends at the Reference and Disposal Sites (Figure A56). There was an increase in these immature worms after the disposal event at the two sites. This was evident at D2. The immature tubificids without hair setae remained constant at the Reference Sites but substantially increased at both Disposal Sites. These oligochaetes had returned to comparable levels the following spring.

107. Since a clearer picture of patterns induced by the disposal event was obtained by examining the major Oligochaeta species groupings over a period of time, a similar evaluation of trends was performed for several species from Tables A6, A7, A11, and A12 that appeared to display definite patterns related to the disposal of dredged material.

108. L. udekemianus (Figure A57) was not found at either the Reference or Disposal Sites prior to deposition. It was present at D2 on 16 November but not on 14 September. However, it was at D8 on the latter date but not on 16 November. Hence, the distribution of L. udekemianus was considered to be patchy. This species reached its maximum in the spring (21 April 1976) well after the event. It never did appear in the reference samples. Peloscolex multisetosus (Figure A57) was found in similar numbers at all sites prior to disposal (30 July 1975). By 5 days after disposal, levels had nearly doubled at C1; a lesser increase also was observed at C3. More than a 50% decline occurred at D2, while numbers nearly tripled at D8. By 30 days after disposal, however, this species had greatly increased in number at D2 and did not return to reference levels by the following spring (21 April 1976). Collections at D8 indicated this species always remained within the range of those observed at the Reference Sites.

109. Another numerically dominant oligochaete, L. hoffmeisteri (Figure A58) also increased in numbers at the Disposal Sites after disposal with the exception that it declined at D8 on 14 September. It generally remained much higher than the references throughout the study. Aulodrilus limnobius, on the other hand, nearly disappeared from the Disposal Sites following disposal. A. limnobius was present at D2 on 16 November. It had not reappeared at D8 even one year later (Figure A58).

110. The remaining oligochaete to show a pattern was Potamothrix vejdovskyi (Figure A59), illustrating the patchiness of these worms. Initially, it was not found in the Reference Site. However, it was observed in low numbers on 19 August (C1 and C3), 14 September (C1 and C3), 16 November (C1 and C3), and 21 April (C3), but not on 8 July. Similarly, it was collected in the reference stations on 19 August (D2 and D8), 16 November (D2 and D8), 21 April (D8), and 8 July (D2 and D8). No conclusions regarding the possible impact of disposal on that worm could be made from such data. The only isopod observed in this area, Asellus sp., was almost totally absent from the Disposal Sites after disposal (Figure A59). It did not reappear at the Disposal Sites in significant numbers until the following summer (8 July 1976) and then only D8 samples were comparable to those from the Reference Sites.

111. The sphaerid Pisidium sp. also exhibited some interesting changes in numbers over time (Figure A60). At C1, the amounts collected increased markedly between 30 July and 19 August. There was a gradual decline to near postdisposal levels by 8 July. However, at the other Reference Site (C3), a similar trend but at much lower total numbers was noted. Following disposal (19 August) there was a slight decline in Pisidium. However, by 14 September the numbers had increased substantially at D8 while none were collected at D2. Numbers remained low at D8 and D2 through July, with the exception of an observation of levels at D2 slightly higher than those at C3 on 21 April. The nematode Dorylaimus sp. exhibited a sharp decline at the reference stations following disposal (Figure A60). With the exception of the

samples from D8 on 16 November and 8 July, this nematode was present in numbers substantially below those at the reference stations. At the Reference Sites, the chironomid _Procladius_ generally increased in number through April followed by a decline in July (Figure A60). _Procladius_ was not collected at the Reference Station D2 until 16 November. However, when it was gathered at D2 on 16 November and 21 April, it was observed in levels above those at the control stations. At Station D8 this chironomid was present but generally in lower numbers than those at the Reference Sites through the course of the sampling. Another chironomid, _Chironomus_, appeared to exhibit more of a negative response to disposal (Figure A60). Following the latter, it was not observed at the Disposal Sites until 16 November and remained below the levels collected at the Reference Sites. However, it should be noted than no _Chironomus_ were collected at any of the above stations on 8 July.

Comparison of river and lake communities

112. Evaluations of the long-term impact of disposal on the benthic fauna stimulated an intensive investigation of the immediate changes that occurred in the benthic habitat following the disposal of dredged material in the open-water lake environment. This investigation included an attempt to evaluate effects not only on the center of a disposal area but also at various distances away from this center.

113. Sampling of the Ashtabula River bottom habitat, the source of dredged material for the 1976 disposal operations, showed that the community was more than 93% oligochaetes (Table A13). The only other taxa collected consistently was the chironomids. Several species recorded were not encountered in the lake environment. These included _Limnodrilus udekemianus_, _L. cervix_, _L. maumeensis_, and _Tubifex tubifex_.

114. The first sampling conducted for the short-term evaluation of disposal was on 15-16 May 1976 to determine similarity between the Reference and Experimental Sites. Initially, there were 4 Reference Sites sampled (C1-C4) and 16 Disposal Sites (SD1-SD16), referred to as

quadrats. The center of the disposal operation included the area covered by quadrats SD6, SD7, SD10, and SD11. Examination of the results from the predisposal collections concerning major taxonomic compositions of these 20 sampling sites indicated a heterogeneous environment (Figure A61), which also was encountered the previous year in this area. The collections from C1 again showed a higher number of sphaerids than the other sites. Samples from several of the experimental quadrats displayed much higher numbers of isopods than others (i.e. SD5, SD15, and SD16). Several experimental quadrats including SD12, SD13, and SD14 were located in a bottom area covered by shale from which it was extremely difficult (often impossible) to obtain samples.

115. A close examination of the species compositions making up the community at each sampling site, using community ordination (log data) revealed that in general the sites were similar (Figure A62). Figure A62 included the results from the analyses of the River collections to compare the similarity of organisms in that area with the experimental disposal area in the Lake. There was considerable difference between the River and open-water Lake benthic communities. In addition, the X-Y axes revealed more separation between the Reference Station C1 and the experimental quadrats than there was between C3 and the same quadrats. This was thought to be due to the large number of sphaerids observed at C1. In relative terms, when one considers the separation between the Harbor and Lake samples, dissimilarity between the different sites within the Lake was minimal.

116. Samples at the two Reference Sites (C1 and C3) and two of the experimental quadrats (SD7 and SD11) were sectioned prior to disposal to record vertical distribution of the benthic fauna between the areas. Figure A63 indicates that the first sediment section (0-5 cm) was very similar with respect to C3 and SD11 collections. Site C1 samples again showed higher numbers of sphaerids. However, with respect to the second and third sections, each station appeared to be unique. It should be noted that the oligochaete portion of each section, although generally greater than 80% of the community, did not represent the entire faunal component as was observed from samples taken after the 1975 disposal

operation.

117. Disposal sampling. During the disposal operation (24 May 1976), a set of samples was taken from Quadrat SD10 during the initial disposal event of the second day and again at the completion of disposal for that day. These samples were sectioned and the results are presented in Figure A64. In general, the total number of organisms per square meter was much greater at the beginning of the day (samples 1-3) than at the end of the day (samples 4-6) for all sections. Besides oligochaetes, chironomids, sphaerids, isopods, nematodes, and gastropods were observed in the first section of samples 1-3. Oligochaetes plus sphaerids, chironomids, and nematodes were observed in the second section of samples 1-3, while only oligochaetes and isopods were seen in section 3 of samples 1-3 (Figure A64). Since this area had also been used for disposal on the previous day, either these organisms had been in the dredged material, had recolonized overnight, or had vertically migrated through the disposal mound from buried sediments below. The final three samples taken at the end of disposal that day showed that the number of organisms had decreased and that several groups such as the gastropods, which were present in low numbers prior to disposal, were not observed and others such as the chironomids had been displaced to the third section. Additionally, polychaetes appeared in sections 1 and 3 of samples 4-6. These organisms were not seen in the Lake earlier but were present in the River (Table A13). The isopods, which also were noted in low number prior to disposal, were almost totally absent and the nematodes appeared to increase in the samples by the end of that day. Leeches were noted in the third section of sample 4.

118. Postdisposal sampling. The first set of the 1976 postdisposal collections was made 5 days after disposal ceased (10 June 1976). The other set of collections were made 30 days after completion of disposal (8 July 1976). Figure A65 illustrates the gross changes that occurred in the benthic communities comparing data from the Reference Sites (C1 and C3) with those from the Center Disposal Quadrats (SD6, SD7, SD10, and SD11). The species number changes were minor among the six sites shown in Figure A65. The C3 collections indicated a slight increase in

the mean number of species over the time period, while C1 exhibited a decline in this parameter. All the Disposal Site collection results showed an initial increase in mean species number similar to those at C3. By 30 days after disposal, however, collections from all disposal sites, except SD11, showed a slight decline in mean number of species. As was noted in the 1975 event, the mean number of organisms per square meter indicated more clearly than other parameters what occurred following disposal (Figure A65). The mean number of organisms per square meter from Reference Sites C1 and C3 changed very little over the time interval and did not change appreciably from 15,000 organisms/m^2. All the samples from disposal quadrats also yielded approximately this same number of organisms prior to disposal. The collections taken 5 days after disposal showed that the largest change had occurred at Quadrats SD6 and SD7. Collections from the other two (SD10 and SD11) did show an increase in their mean numbers but to a lesser extent than the SD6 and SD7 levels. Samples taken 30 days after disposal (8 July) on the disposal quadrats showed that the mean number of organisms on SD7 had continued to increase and that SD11 counts also had increased to approximately the same level. The SD6 data on the other hand showed a decrease in mean total number of organisms and SD10 results, although indicating an increase, only reached the number of organisms per square meter to which SD6 had declined.

119. The 5-day and 30-day postdisposal results for the 1976 (short-term) disposal event were evaluated with discriminant analysis to determine which sites were similar to the Center Disposal Quadrats (SD6, SD7, SD10, and SD11) may have been impacted by disposal of dredged material. The results of these analyses also were used to determine if there was a significant difference ($P < 0.05$) between the Reference and Disposal Site communities and to identify the faunal groups most responsible for this discrimination.

120. Table A14 shows that besides the Center Disposal Quadrats, the SD1, SD3, and SD15 communities were different from the Reference and assumed to be impacted by the disposal event. The Reference Site communities were determined to be significantly different from those on

the center disposal sites at the 0.05 level. Evaluation of the mean numbers per square meter for each of the major faunal groups (Table A15) indicated quite marked differences between Reference and Disposal Sites. Especially important was the ratio between oligochaetes and total number for each set of sites, a pattern also observed in 1975 (Table A10). The faunal groups identified as most powerful in discriminating between the Reference and Disposal Sites were _Limnodrilus_ spp., Chironomidae, and _Aulodrilus_ spp. This was evident when the means and standard deviations were examined for each of these groups (Table A15).

121. The collections made 30 days after disposal showed that the quadrats that were similar in comparison to the Center Site 5 days after disposal, excluding the Center Quadrats, supported communities very similar to the Reference communities. The Reference Site and Center Disposal Site communities still differed significantly ($P < 0.001$) (Table A14). There was an appreciable difference in the ratio of oligochaetes to total numbers for the two areas as well as a complete absence of isopods and gastropods collected from the Disposal Quadrats. The faunal groups identified by the discriminant analysis as being most important (effective) in differentiating the communities were the isopods, the oligochaetes, and the species group, _Limnodrilus_ spp. (Table A15).

122. The determination of similarity using community ordinations between all samples collected 5 days after disposal is represented in Figure A66. The results from Disposal Quadrats SD6 and SD7 showed the most dissimilarity to Reference Station C3. The X-Y ordination axes also indicated considerable separation between the Disposal Quadrat samples SD10 and SD11 and the Reference Station C3 results. Disposal quadrat data from SD5, SD8, and SD9 showed slight dissimilarity while the quadrat results from SD4 and SD16 were similar to those for the reference station. Data from several of the disposal quadrats were not illustrated because samples were not taken due to the presence of shale.

123. Illustration of the group composition for each of the sampling sites (Figure A67) indicated that the only real differences between the Reference Site (C3) collections and those from Disposal

Quadrats SD4, SD5, SD8, SD9, SD15, and SD16 were the low number of gastropods at several sites, as well as the low number of nematodes on others. SD8 collections also showed a much higher total number of organisms per square meter than the others (excluding the center quadrats). The oligochaete composition ranged from approximately 60-90% of the community on each site. The collections of the Center Disposal Quadrats (SD6, SD7, SD10, and SD11) yielded mean numbers of organisms per square meter between 18,000 and 65,000. More than 97% of these organisms were oligochaetes. The diversity of other groups had drastically decreased. A few turbellaria, sphaerids, chironomids, and nematodes were the only significant organisms other than oligochaetes observed. Isopods reached their peak during this period (Figure A35) but were absent from SD6, SD7, SD10, and SD11.

124. Core samples taken at C1, C3, SD7, and SD11 were divided into three segments (0-5, 5-10, and 10 cm). According to the analysis of these samples gathered 5 days after disposal (Figure A68), oligochaetes comprised the majority of organisms in all sediment sections of the two disposal quadrats. Nematodes were the only group seen deeper than the first section on Quadrat SD11. Sphaerids and gastropods as well as the nematodes were present in the deeper sediments from SD7. Chironomids were absent on both disposal sites except for a small number in the top section. Chironomids were distributed in high numbers throughout the sediment sections collected from the Reference Sites.

125. Analyses of community similarity (ordinations) on the samples collected 30 days after disposal (Figure A69) showed that SD7 and SD11 were the quadrats for which samples were most dissimilar to those from Reference Sites. SD6 and SD10 collections were also quite dissimilar to the references and, along with the SD7 and SD11 samples, were of considerable distance from the other disposal quadrats on both sets of axes (X-Y and X-Z). The major causes for these dissimilarities were believed to be the extremely high total number of organisms collected from the Center Disposal Sites (Figure A70) and the lack of most major groups except the

oligochaetes. Disposal Quadrats SD1, SD2, SD3, SD4, and SD8 data separated slightly from the references (Figure A69) primarily because they consisted of fewer numbers of isopods (Figure A70). Quadrats SD9, SD15, and SD16 results differed from the reference results as well as those from SD1, SD2, SD3, SD4, and SD8 (Figure A69), primarily due to the lower numbers of both isopods and sphaerids observed at the former as compared to the latter group.

126. Evaluation of the sediment sections from the Reference Station C3 and the two Disposal Quadrats SD7 and SD11 30 days after disposal (Figure A71) showed that all groups other than the oligochaetes had almost entirely disappeared from each section of the disposal quadrat cores. The only exception to this was a small number of sphaerids observed in the third section of SD7. The Reference Site data, on the other hand, displayed a great deal of diversity in groups throughout the vertical sections. The isopods, gastropods, sphaerids, and nematodes were found at all depths in the sediment.

127. Similar to the long-term monitoring of disposal impacts on the benthic fauna, an evaluation of changes in specific organisms (species) over the sampling period provided some valuable insights into the effects of open-water disposal on the benthic fauna. The immature tubificids both with and without hair setae (Figure A72) showed the same patterns as observed immediately after the 1975 disposal operation. They were both present at all sites prior to disposal as well as in the River and Harbor (the source of disposal material). Both also were observed during the disposal operation. After disposal (5 and 30 days) large increases in immature tubificids without hair setae were seen at all disposal quadrats. Collections (10 June) at SD6, SD7, and SD11 initially indicated increases in immature tubificids with hair, while the number of these worms at SD10 remained at the level found in the Reference Site. Collections made 30 days after disposal indicated that this group had now increased at SD10, remained high at SD7 and SD11, and decreased to reference levels at SD6.

128. Four species of oligochaetes that were observed in various numbers at the Disposal Quadrats after disposal (Figure A73) were never seen at the Reference Site and were not observed at the Disposal Sites prior to disposal. All of these species, Limnodrilus udekemianus, L. cervix, L. maumeensis, and Tubifex tubifex were observed in high numbers in the River samples. In addition, all were seen at SD10 during the disposal operation. Therefore, it can be assumed that these species were able to colonize on the Disposal Quadrats because they were transported to these sites with the dredged material. Furthermore, they were all able to maintain their numbers on at least some of the quadrats as long as 30 days after the disposal event. L. cervix appeared to be very successful on all sites. L. udekemianus did not immediately inhabit SD6 and later disappeared from SD10 as did L. maumeensis. Tubifex tubifex eventually disappeared from SD6 (Figure A73).

129. Three other oligochaete species (Figure A74) were present in the Lake prior to disposal and showed varying reactions from the disposal events. L. hoffmeisteri was present at all sites in similar numbers before disposal. This species showed an increase in population size during disposal that continued and increased on certain disposal quadrats (SD6, SD7, and SD10) 5 days after the event. The samples taken 30 days after disposal showed this species had disappeared from the Reference Site but remained numerically at equal levels at the Center Disposal Quadrats. L. claparedianus (Figure A74) was very abundant in the River samples, but only present on two sites prior to disposal. During disposal this species exhibited a sizable increase at SD10 where it was not present before. While never occurring at the Reference Site, it was represented in large numbers 5 days after disposal at all the Experimental Quadrats (SD6, SD7, SD10, and SD11). Collections 30 days after disposal indicated that this species was present only on SD7 and SD11, a pattern also seen prior to disposal. Aulodrilus americanus was reported in very low numbers from the River samples and seen in greater numbers at all the Lake sites prior to disposal (Figure A74). During disposal this

species also was observed at SD10. In the samples taken 5 days after completion of disposal (10 June) A. americanus was observed at both the Reference Site and Disposal Quadrat SD11. The numbers increased at Station C3 30 days after disposal (8 July), increased slightly at SD11, and reappeared at SD6. Collections at SD7 and SD10 did not indicate the presence of this species after disposal.

130. The dynamics of an isopod, gastropods, and a chironomid were examined during the short-term monitoring of disposal in 1976. The isopod Asellus was not seen in the Harbor samples and was one of the few species to show a decrease in number between the beginning and end of a day-long (24 May) disposal operation at SD10 (Figure A75). Prior to disposal, Asellus was present on all sites with maximum numbers at SD10. The 5-day postdisposal collections indicated that this isopod had increased in numbers at the Reference Site, decreased over predisposal levels at SD7, SD10, and SD11, and disappeared from SD6. By 30 days after disposal, the isopod had disappeared from all the Center Disposal Quadrats and more than doubled in number at Reference Station C3. The gastropods Valvata spp. showed similar trends to the isopod (Figure A75). These were found in small numbers in the Harbor samples and were observed on the Reference Station C3 and Disposal Quadrats SD7 and SD11 prior to disposal. A very low number were seen in the samples taken during disposal. After disposal, the gastropods were observed in high numbers at the Reference Site and on the Disposal Quadrat SD10. The quadrats supporting these species prior to disposal were void 5 days after. Collections 30 days after disposal exhibited Valvata present only on the Reference Sites. Procladius sp., a chironomid, was observed in very high numbers prior to disposal at all sites (Figure A75) and also present in low numbers in the Harbor samples. Five days after disposal (10 June) this species had decreased at all sites, including the Reference, but showed numbers between sites in similar ratios as those observed prior to disposal. Collections from the Reference and Experimental Sites 30 days after disposal indicated stable conditions on C3, decreased numbers on SD10 and SD11, and the absence

of *Procladius* sp. from SD6 and SD11.

Summary

131. In summary, various effects were evident from the detailed examination of the impact of dredged material disposal on the species cited above. Four species of oligochaetes that were absent in that area prior to disposal appeared and thrived on the disposal quadrats. Two more oligochaetes plus the immature forms increased in numbers on the disposal quadrats after the disposal of dredged material. The oligochaete *Aulodrilus americanus* exhibited an adverse effect from disposal. The species other than the oligochaetes were all adversely affected in terms of numbers by the disposal event with isopods and gastropods showing the most extreme reaction of all the species studied.

Meiobenthos

132. The meiobenthic fauna, multicellular organisms less than 1.00 mm in size, are considerably more diverse than the macrofauna of most benthic habitats (Moore 1939, Dineen 1953, Cox 1976). Typical meiofaunal benthic communities contain representatives of most major invertebrate taxa, including the Nematoda, Copepoda, Turbellaria, Ostracoda, and Oligochaeta (Moore 1939, Dineen 1953). The meiofauna of most benthic systems (both marine and fresh water) appear to be relatively isolated systems. Little evidence exists concerning external predation, except for the few organisms that actually ingest sediment to derive their food sources (McIntyre 1969). Most meiofauna live within the pore spaces of the sediment and are adapted to move freely in this space without displacing any particles. In many finer sediments, such as those found in Ashtabula, many of the pore spaces decrease and thus, a number of burrowing meiofaunal forms may numerically exceed the interstitial types which inhabit the pore spaces. Immature forms of several macrobenthic fauna also belong to the meiofaunal system during certain periods of their development.

133. Meiofaunal counts were made on the benthic samples of the Reference Stations (C1 and C3) and two sets of Center Disposal Sites, D2 and D8 - 1975, and SD7 and SD11 - 1976, during several sampling periods throughout the study. The Oligochaeta and Nematoda, two of

the most numerous groups within the meiofauna, displayed trends very similar to these same groups of the macrofauna. Since species identifications were not routinely done on these groups, no further new information could be added to what was previously stated regarding the macrofaunal results. Two groups of meiofaunal organisms that showed some impact from the disposal of dredged material and were not observed in the macrofauna in great numbers were the Ostracoda and Harpacticoida.

134. The ostracods displayed a definite increase in numbers following the disposal of dredged material in both study years (Figure A76). Conditions at both Reference and Disposal Sites were similar prior to the disposal event. Samples collected 5 days after disposal (19 August 1975 and 10 June 1976) exhibited large increases in number at the disposal sites, while the Reference Site data remained fairly constant with respect to the number of ostracods. Exceptions were a decrease at C1 and an absence at C3 on 19 August and 16 November. The long-term evaluation of disposal impacts (1975) showed that after the initial major increase at the Disposal Sites (5 days after disposal) there was a decline (16 November 1975) with ultimate disappearance of this group (21 April 1976) from the disposal station collections. The Reference Sites continued to support a small population of ostracods throughout this period. The 8 July 1976 samples (Figure A76) from the Control and Disposal Sites revealed that all areas supported similar numbers of ostracods with the exception of D2 which had a somewhat higher population.

135. The harpacticoid copepods, which were almost totally represented by Canthocamptus sp., did not show consistent patterns throughout the study duration (Figure A77). This was partially the result of their life cycle. During certain periods of the year, this group of animals encysted in the bottom sediments (Cole 1953). This morphological stage is very difficult to identify and, consequently, could not be readily differentiated from other sediment material. Therefore, these were not often considered.

136. The long-term evaluation of disposal (1975) was the only data that illustrated any impact from disposal for the harpacticoids (Figure A77). Group numbers were relatively similar between the Reference and Disposal Sites prior to disposal (C1 compared to D2 and C3 compared to D8). Immediately after disposal there appeared to be no real change in the pattern with a decrease observed at all sites. A closer examination of the results of this sampling period (5 days after) as illustrated in Figure A78 indicated that the cause of decrease in numbers was because the majority of organisms were in the encysted stage at the Reference Sites (C1 and C3). As indicated above, identification of cysts was very difficult and time-consuming. Therefore, Figure A78 contained the results for only one of the four replicates taken at each station. The results, however, were still informative. They indicated that the majority of harpacticoids found at C1 and C3 were in the encysted stage while there were neither cysts nor active forms observed at D2 or D8 in great numbers. Therefore, the results indicated that the harpacticoids were affected by disposal in some fashion.

137. The fall season, after the Lake overturned, was the period when harpacticoids were normally found in their most active stages as opposed to normal summer encystment (Moore 1939). The samples taken 90 days after disposal (16 November), therefore, should have shown active forms of this group. Station D8 collections exhibited a slight increase over those from the references (Figure A77) while D2 collections were very low in number and different from the references, a pattern also observed for the macrobenthos during this sampling period (Figure A47). The following spring the Reference Site samples were characterized by large increases in harpacticoid numbers. Station D2 collection was still very low, and D8 samples remained in numbers at the same level observed the previous fall. An examination of immature forms and females carrying egg sacs indicated that approximately 50% of the harpacticoid count on C1 and C3 were immature and of the mature females, 24% carried eggs (Evanko 1977). This implied that during late winter and early spring, reproduction occurred in this group which other investigators also observed (Moore 1939, Dineen 1953). This fact accounted for the increased numbers at the Reference Sites, a pattern not observed on the Disposal Sites. The

collections of 8 July 1976, approximately 1 year after disposal, illustrated that the harpacticoid populations had become very similar in number between both the Reference and Disposal stations. These samples were obtained at the beginning of their period of encystment. Therefore, while the cycle of encystment may have been altered by disposal, the organisms had adjusted and predisposal conditions were reestablished.

PART VI: DISCUSSION

Impact on Pelagic Community

138. The results obtained from monitoring the pelagic environment for changes in floral and fauna communities following the open-water disposal of dredged material indicated, in general, that most effects were immediate and that in only a few instances were any possible long-term impacts noted. Initial biological changes after disposal were reflected by alterations in pigment concentrations (Figure A17) taken near the bottom of the water column. There were steady declines in chlorophyll a concentrations observed between the 12 and 14 m depth below the surface at increasing distances downcurrent from disposal and at increasing time periods after the event. This phenomena may have been related to the movement of a disposal plume just above the bottom sediments of the entire area surrounding the disposal site. Since there were no real differences observed with depth for chlorophyll a concentrations prior to disposal (Figure A16), this trend indicated a possible relationship to the disposal.

Bioassay

139. Stimulation as well as toxicity have been observed for phytoplankton in bioassays with disposal elutriate conditions (Shuba, Carrol, and Tatum 1976). The results of the elutriate-primary productivity bioassay conducted as part of this investigation indicated that the disposal impact on phytoplankton was adverse (Table A5) at most concentrations. Two of the four bioassays (11 June and 14 September) did show stimulation of photosynthesis at the lower concentrations and the 14 September stimulation was significant ($P < 0.04$). At higher concentrations of elutriate addition, the phytoplankton exhibited inhibition in photosynthesis (Figures A31-A34). The cause of stimulation in some cases and decline in others for photosynthesis cannot be determined from the data amassed. The inhibition of productivity was observed, however, especially at concentrations in excess of 15.0 mℓ of elutriate addition. As Shuba, Carrol, and Tatum (1976) stated, the bioassays indicated bioavailability of dissolved constituents released during dredged material disposal and the exact effect of these upon the

primary producers. Since the observed productivity for the different elutriate additions was not the same as the productivity observed using the disposal site water (controls), and in many cases was significantly different (Table A5), a possible impact on the phytoplankton was implied. Above certain concentrations a toxicant appeared to depress bioactivities while at lower concentrations the toxicant may have acted as a stimulant similar to the phenomena (Hueppe's Principle) observed by Bollen (1961) for microorganism responses to pesticides. These varied responses suggested that the degree of mixing and diffusion of the disposal site water with the dredged material depositions must be considered when fully evaluating the bioassay results.

Disposal sampling

140. The pelagic impact also was evident from samples of phytoplankton, pigments, and zooplankton collected on the last day of disposal operations (Figures A18 and A19). There were no decreased numbers of phytoplankton observed at the disposal sites as compared to the control sites. Chlorophyll concentrations collected near the bottom were somewhat lower at the disposal sites. Although difficult to definitely relate to the disposal event, based on the discussion above, no major inhibition from disposal could be concluded. The return to similar conditions for all sites within 5 days after disposal (1975) implied that the impact observed was short-lived for the majority of the water column in the area sampled.

Postdisposal sampling

141. There were some possible increases observed 5 days after the 1976 disposal event in the crustacean zooplankton populations on two (C3 and NDS) of the sites (Figure A27), one of which was NDS. The dredged material was shown to contain a very high content of ammonia (Great Lakes Laboratory 1977). It has been shown in several instances in the past that zooplankton populations in Lake Erie have been related to high concentrations in ammonia, suggesting a detrital rather than a herbivore-based food web (Gliwicz 1969, Great Lakes Laboratory 1976a). A similar set of circumstances could have occurred after the disposal event in 1976, resulting in higher numbers of zooplankton to concentrate over the disposal area as long as 5 days after the disposal. These observations

may have been related to the crustaceans seeking resuspended detrital matter for food. However, these conclusions should be tempered by the normally patchy distribution of zooplankton in Lake Erie (Great Lakes Laboratory 1976a).

142. An additional effect of disposal suggested by the results observed for the elutriate-primary productivity bioassay was the addition of large amounts of suspended particles in the water column. After observing the results of two of the bioassays that exhibited suspended particles in the incubation bottles (Figures A31 and A32), it was assumed that heterotrophic activity could have been increased substantially when the bacteria were provided with suitable substrates for colonization. If these results were applied to conditions in the water column, one could assume that bacterial activity from disposal would have increased and may have limited the amount of oxygen, not only in the water column while the particles were settling, but also in the bottom waters once these particles with bacterial growths had reached the sediment surface. Paerl (1974) found that detrital particles settling through the water column stimulated bacterial growth and that these clusters of detritus grew in size as the rapid heterotrophic activity caused additional particles to adsorb to the filaments of the initial growth. This phenomenon could have had a definite effect on the biochemical oxygen demand (BOD) of the immediate disposal area. However, given the rapid settling of suspended material following disposal as well as the small number of these particles that are at the surface-water interface in contrast to those that are buried, these impacts are considered to be minor.

143. Several isolated results were observed during various sampling periods following the 1975 disposal operation that may have been related to impacts on the pelagic habitat. Increases in bottom pigment concentrations were observed 5 days after disposal at the Experimental Sites (Figure A20) that were similar to concentrations at the sites near the mouth of the Ashtabula River. These increases may have been related to either resuspension or simply

release of disposed sediment constituents during disposal. Thus, processes were still occurring in the bottom waters that may have been related to the disposal operation. The zooplankton collections also indicated a different trend on the Disposal Sites for the 14 September sampling (Figure A23) as well as the 19 October collections (Figure A23). In both instances, the total numbers of organisms were much lower than at the other sites. Since the collections were made via plankton tows from the bottom to the surface and all stations were approximately the same depth, the numbers should have been similar. Populations are normally found in the deeper waters during daylight (Hutchinson 1967), the period when the collections were made. Since there were not as many organisms observed on PW3 and PW5, the crustaceans may have been avoiding the immediate bottom area near the disposal mounds, causing lower numbers to occur in the plankton nets. However, the patchy distribution of Lake Erie zooplankton may have again accounted for all or part of these observations.

Impact on Benthic Community

144. A completely different situation was noted over the extended period of observation concerning the benthic faunal communities following the disposal of dredged material. Not only was there an immediate impact on this component, but it also still showed effects on the communities long after completion of disposal. Thus, as would be expected, the major emphasis of this investigation was placed on the benthic environment. Since this appendix only concentrates on the changes in the flora and fauna related to the disposal of dredged material and does not include physicochemical results, only a general treatment of the changes in the benthic community will be discussed below. Specific observations are discussed in the main text in relation to the physicochemical data.

145. The first 30 days after the disposal period appeared to be the most critical for the benthic communities that had been disposed upon during the operation. This was a major consideration regarding the 1976 experimental design which was to intensively study the dynamics of impacted communities. What occurred in the

first 30 days played a major role in the events taking place later in the study on the Disposal Sites. The general trends observed for the Disposal Sites included relatively no change in species number at most locations over the first 30 days. The total number of organisms, however, increased immensely (Figures A39 and A65). The fact that many faunal groups had disappeared from the Disposal Sites during this interval, coupled with the observations of no real species number changes and large organismal number increases, indicated that new species had replaced the eliminated ones. Also, these newly introduced fauna were able to temporarily increase in numbers within the changed environmental conditions at the Disposal Sites. The faunal changes, including the resulting distribution pattern with time, were characteristic of a variable community (Pielou 1975). Examples of this instability were the large increases observed for total numbers associated with the high standard deviations (Figure A65), especially at SD7 and SD11 in 1976. Replicate samples obtained from the same immediate areas were very different, suggesting extreme patchiness or high variability in populations and general instability.

Vertical distribution

146. Analysis of vertical distribution of fauna within the sediment is very important in relation to bioturbation and the availability of benthic fauna to other trophic groups (Kajak 1971). In many instances the maximum biomass can be found in deeper sediment layers (Lenz 1931, Coleman and Hynes 1970) and comprised primarily of larger organisms. This phenomenon was observed in the present study at the Reference Sites (Figure A36). The trend after disposal did not show this to be the case, however, for the Disposal Sites. The collections of vertical sections 5 days after disposal (Figure A43) indicated that any larger organisms present (e.g., chironomids and isopods) were found only in the surface layers and that by 30 days after disposal (Figure A44), they had disappeared from all stations. Since there fauna did not vertically distribute themselves, they were subject to both predation and physical forces, which added

to the instability of the communities observed on the Disposal Sites. A possible cause for these organisms not moving into the sediment was related to the environmental conditions of the deeper layers. Low oxygen concentrations, low interstitial water content, increased compaction, and highly reducing conditions can result from the burial of natural lake bottom sediments (Oliver and Slattery 1976). Consequently, it was assumed that these organisms would not survive in the deeper sediment layers; therefore, they either migrated to another more favorable location or were eliminated by the above physical and/or biological pressures. However, such disappearance and increased instability were not evident during this experiment (Figures A39 and A65).

147. The preceding description of the response of the benthic communities after disposal was not very similar to changes described in some other benthic environments that were impacted by pollutants. Perturbations ranging from extreme environmental alterations (i.e. oil spills) to normal seasonal or daily water-level fluctuations have been shown to create unpredictability in aquatic benthic environments (Sanders 1969, Slobodkin and Sanders 1969). These events caused the number of species to decrease and resulted in instability in the community. Slobodkin and Sanders (1969) stated that species in a low predictability environment would be subject to more probable extinction and less probable speciation than species in high predictability areas. The patterns observed for the disposal communities compared to the Reference communities did not generally follow this pattern.

Discriminant analyses

148. The results from the discrimination analysis provided valuable information concerning the disposal event and its impact on both the immediate benthic habitat as well as the habitats in the general area (described by the different sampling site locations, Figure A4). The 1975 disposal operation of Harbor dredgings impacted an area covered by most sampling sites, as indicated by faunal community compositions 5 days after disposal at these sites (Table A9). Three of the five sites supported

communities similar to the center disposal site (D2). The results of the River dredging disposals (on D8) indicated that only Station D8 was impacted initially (Table A9). The two outlying down-current sites (D6 and D12) were not initially affected by disposal. In 1976, according to similarities in communities (Table A14), the impact of disposal was noted on Quadrats SD1, SD3, and SD15 (Figure A10) besides the center disposal sites, an affected area slightly larger area affected than during 1975. The remaining quadrats sampled (six) showed no change in community structure. Consequently, it appeared that the initial disposal impact was confined to a relatively small area and was more a function of the actual path of the hopper dredge during disposal. The results 30 days after disposal, however, did not show the same pattern. Several sites from the 1975 disposal event supported communities comparable to those at the center disposal sites 30 days after disposal. These similarities were not observed 5 days after disposal. Three additional locations (D3, D7, and D9) supported communities similar neither to those at the center disposal sites nor the references. As stated in Part V, these stations exhibited much higher numbers of mobile faunal groups, such as the isopods, than the reference locations. Therefore, it was assumed that many of the fauna that disappeared from the center disposal sites as described previously were probably migrating to areas of higher predictability (Slobodkin and Sanders 1969) that were much less affected than the center sites.

149. The same phenomenon was not noted during the 1976 operation 30 days after disposal. By the 30-day sampling event all quadrats (Table A14) except for the four center sites displayed conditions similar to those at the Reference Sites (Figure A77). These differences in faunal movements were explained in part by the differences in distance between quadrats compared to the distance between sampling stations for 1975. The quadrat distances (1976) were much greater, and the migration of species away from the center sites did not cover these greater distances. Movement of the more mobile and less tolerant species from the

low predictability areas (center disposal sites) to the more stable higher predictability areas of the bottom habitat appeared to be one of the consequences of the disposal impact on the benthic environment. As Sanders (1969) stated, invasions of more stable areas are likely to be in response to perturbations in the environment's immediate past, resulting in underexploitation of resources or space. This appeared to be the situation in the nearshore waters of Ashtabula if one considers the past history of disposal in this area (see Part I).

150. The continuation of sampling for 1975 indicated that even 90 days after disposal (Table A9), the areas quite distant from the center sites, D6 and D12 (Figure A4), supported communities that showed similarities to those of the center sites. Since these areas were not initially affected by disposal, it was assumed that with time the impact of disposal spread as less tolerable species initially invaded other environments. Later, even the populations thriving on the center disposal sites (e.g. Limnodrilus hoffmeisteri, Peloscolex multisetosus, and Potamothrix vejdovskyi) thriving on the center disposal sites expanded their range due to competition pressures from increased numbers.

151. The fact that perturbations on the benthic environment have been shown to result in the underexploitation of resources and space (Sanders 1969) perhaps explains in part the observed appearance of amphipods in the samples taken from D2 almost a year after disposal (Figures A40 and A54). However, they did not appear in the Reference Site samples. The amphipods were able to occupy some available space and/or utilize some available resources (i.e. food) at the Disposal Sites, which perhaps were indirectly related to disposal of the previous year.

Dredged Material Sources

152. The 1975 disposal operation was especially informative because dredged material from two different sources was disposed of on the Experimental Sites (River dredgings on D8 and Harbor dredgings on D2). The results observed suggested that the two center disposal

sites differed from the Reference Area because of the disappearance of the isopods, chironomids, etc. (Table A10), and the increase in oligochaetes, especially L. hoffmeisteri, which were abundant in both the River and Harbor and are indicators of more polluted conditions (Brinkhurst 1967). The two disposal sites, however, also differed from one another due to the difference in oligochaete species observed and the total numbers of organisms supported. Station D8 collections displayed a much greater abundance of Aulodrilus spp. after disposal, especially A. americanus, than did Station D2. The D2 collections showed much higher numbers and more species of Limnodrilus spp. than D8 (Tables A11 and A12). Site D2 samples also exhibited much higher total numbers of all organisms that indicated that many of these had been imported from the Harbor habitat, an area that also exhibited much higher total numbers of organisms than the River (Table A8). The preceding suggest that it is very important to consider the communities and physicochemical conditions of the material to be dredged in respect to the properties of the habitat receiving the dredged material during disposal. Obviously from the results presented, it was apparent that the two disposal site communities responded in completely different ways following disposal and continued to show differences throughout the study, even with respect to recovery of these communities.

Species dynamics

153. One of the important observations derived from this project was the fact that, in many cases, actual effects of the disposal event on the benthic fauna were not evident until the dynamics of individual species were closely examined. There were a number of gross changes that occurred, such as increases in total number of organisms, increases in percentage of oligochaetes in the total community composition, and decreases in many of the other common groups (e.g., nematodes, chironomids, and isopods). As indicated previously, the fact that no gross changes were observed in total species with time possibly was misleading. The observation that many species were eliminated and replaced by others previously not noted in the area was not readily apparent from the presentation of species number for each site over time (Figure A39 and A65). Therefore,

examination of several of the species within the major faunal groups observed during this project was an essential part of the evaluation process concerning a comprehensive treatment of the impacts of open-lake dredged material disposal on the benthic fauna.

Polluted environment

154. The Oligochaeta have been identified as a possible indicator of polluted environments (Goodnight and Whitley 1960). This indicator also appeared in the situation from the Ashtabula study. The oligochaetes represented more than 95% of the community in most of the Ashtabula Harbor and River samples taken both in 1975 and 1976. The percentage of this group was always large at the disposal sites, especially for the 5- to 90-day sampling periods (greater than 98%). Goodnight and Whitley (1960) suggested that a population of 80% or more of oligochaetes in the total benthic macroinvertebrate community indicated a high degree of either organic enrichment or industrial pollution. They also suggested that oligochaete compositions between 60 and 80% indicated questionable pollution conditions. Most of the Reference Site communities were characterized by oligochaete compositions in the latter classification group. Therefore, one of the obvious effects of disposal was the increase in oligochaete dominance observed on the Disposal Sites (Table A10 and A15). Evaluation of some of the generic components comprising this dominant group revealed patterns that could be related directly to the process of deposition. The ratio of *Limnodrilus* spp. to *Aulodrilus* spp. was changed markedly after disposal occurred (Figure A55, Tables A10 and A15). Most Disposal Site oligochaete groups were composed primarily of *Limnodrilus* spp. with *L. hoffmeisteri* being the numerically dominant taxa, while the Reference Site oligochaete groups consisted largely of *Aulodrilus pluriseta*. Brinkhurst (1967) suggested that the percentage occurrence of *L. hoffmeisteri* in relation to other oligochaetes may prove to be a useful indicator of organic pollution. This was observed for the River samples and, to a lesser extent, the Harbor samples (Tables A8 and A13). Similar conditions appeared to be created by the disposal process in the open lake since *L. hoffmeisteri* not only increased but also maintained extremely high numbers throughout the study duration at the disposal sites (Figures A58 and A74).

155. A number of the species encountered after the disposal event were not seen prior to deposition in the Lake environment. These included L. udekemianus (Figures A57 and A73), L. claparedianus (Figure A74), L. cervix, and L. maumeensis (Figure A73). T. tubifex, although observed in the Lake habitat at various times within the collections from the Reference Sites, never exhibited great abundances similar to those observed in Disposal Site samples after disposal (Figure A73). The species mentioned above were all recorded in large numbers in the River and Harbor samples, suggesting that these may have been imported to the Lake habitat during the disposal operation. The fact that they were able to survive, increase in number (in many cases), and even invade other immediate areas suggested that the environment had been altered by disposal and had become conducive to the production of foreign species associated with more polluted habitats. The presence of several such species, including L. udekemianus (Figure A57), was observed even the following summer, almost a year after the 1975 disposal event. The majority of the rest of the oligochaete species examined individually increased in numbers at the Disposal Sites compared to the references. This probably was due to increased organic matter accumulation (Goodnight and Whitley 1960) plus expanded community space and resources left available with the disappearance of several of the less-tolerant species (Sanders 1969). One oligochaete species, A. limnobius (Figure A58), disappeared from some Disposal Site collections and decreased in numbers in others after the deposition operation. This pattern was similar to that discussed previously for the ratio of Limnodrilus to Aulodrilus observed in the Disposal Site samples compared to those from the Reference Site samples.

156. Other species (in addition to those belonging to the Oligochaeta) showed adverse responses to disposal. The chironomids, Chironomus sp. and Procladius sp., disappeared 5 days after disposal at the Disposal Sites in 1975. Chironomus sp. never returned to reference-level numbers over the entire study duration (Figure A60). Procladius sp. (Figure A60) appeared to recover on

the Disposal Sites 90 days after disposal but then was almost totally eliminated the following spring at D8. This may have been related to natural processes in the Lake causing a release of some toxicant on this disposal site or else an effect on the organism's annual life cycle that inhibited a recovery from the disposal perturbation over the study duration. The gastropods, Valvata spp., also exhibited adverse effects from disposal (Figure A75) as indicated by their complete disappearance at two of the three disposal sites 30 days after dredged material disposal. The isopod Asellus sp., as discussed previously, also was severely inhibited from populating the Disposal Sites after disposal.

157. An interesting contrast was observed between the data concerning the Isopoda and Ostracoda, both members of the class Crustacea. As already indicated, Asellus was severely impacted. The ostracods, on the other hand, exhibited large increases immediately after the disposal event (Figure A76). The fact that the numbers at the Disposal Sites were similar to the references 90 days after disposal suggested that two different species may have been causing the trends observed. Ostracods were observed in the River sediments (Table A13). There was a strong possibility that these species were transported in the dredged material to the Lake habitat, in a manner similar to many of the oligochaetes. Consequently, when disposal occurred, these River species replaced the Lake species and were able to thrive. Cole (1953) indicated that some species of ostracods choose softer sediments than others because of their burrowing habits. In addition, this group has been cited for their ability to withstand severely stagnated conditions (Moore 1939) that may have occurred in the deeper sediment layers. With time as well as erosion and/or compaction of the sediments (Oliver and Slattery 1976), the imported species appeared to be replaced by the Lake species migrating from other areas.

158. Another crustacean member, the harpacticoids, displayed an adverse response to disposal similar to that exhibited by the isopods. This effect was believed to be related to the life cycle

of the animal because of the reaction of encysted stages (Figure A78) that were the dominant forms of this organism during the period of disposal. Very few cysts were observed in the Disposal Sites compared to the references after disposal. The apparent disappearance of these forms, a major part of the organism's life cycle (Dineen 1953), did not have a major effect upon the populations observed throughout the remainder of the long-term study (Figure A77). While numbers remained low at the Disposal Sites, there was a return to predisposal levels which was observed almost a year after disposal.

Importance of Life Cycles

159. The observations concerning individual species and their respective responses to disturbances of benthic habitats caused by major disposal operations demonstrated that it is important that considerations be given to the life cycles of both flora and fauna in planning and evaluating the disposal of dredged material in the open-lake environments. Obviously, possible impacts on the phytoplankton are important since this component represents the basis of the trophic structure in lacustrine environments. The effects, however, on this floral component were minimal within days of the disposal event itself, based on the observations during the study. In addition, most species were present in the pelagic environment throughout the year while only their total numbers were dictated by environmental conditions. This plus the constant movement (mixing) of water masses suggested that phytoplankton recovery from disposal is very likely in a short period of time. Reproduction of floral species, therefore, would not appear to be inhibited.

160. This situation may not appear to hold true for the more complex life cycles of the aquatic faunal species, particularly the benthic forms. If environmental conditions are altered during the fall season, cladoceran egg production and subsequent hatching will be altered (Pennak 1953, Brooks 1959). Male cladocerans occur when specific environmental conditions, including temperature, photoperiod, water chemistry, and population density, prevail. For most species the most ideal conditions occur in the

fall (Hutchinson 1967). Copepod and cladoceran eggs produced during the reproductive season will overwinter on the Lake bottom and become a part of the planktonic population the following spring (Pennak 1953, Hutchinson 1967).

161. These patterns were observed for the crustacean zooplankton encountered in the nearshore waters of Ashtabula, Ohio (Figure A12). Minimal levels were observed in the fall when reproduction occurred and the peak in numbers occurred the following spring after the eggs had overwintered on the bottom. If disposal had occurred either during the egg production period in the fall or while the dormant eggs were overwintering, the spring population densities may have been affected. This, in turn, could have had an impact on the biota of the entire area since some of the fish depend upon zooplankton for food. A reduction in phytoplankton grazing by the herbivorous species of zooplankton could also alter phytoplankton assemblages.

162. As previously emphasized, many of these pelagic impacts would probably be only temporary because of the constant water circulation and movement of water masses from other areas into the vicinity of the Disposal Sites.

163. Contrary to the above, the impact on benthic fauna, as illustrated by much of the long-term investigation data, may not be temporary because these components of the Lake biota are more stationary in comparison to the pelagic inhabitants. The general trend for the oligochaetes indicated that the life cycles for the majority of the genera were not inhibited by the disposal event but rather were stimulated. Increased numbers of the immature forms, especially the immature tubificids without hair setae, primarily represented by the genera Limnodrilus, occurred at all Center Disposal Sites after disposal. They were present in extremely high numbers at many of these locations throughout the study period. The fact that this group normally reproduces throughout the majority of the year (Brinkhurst and Jamieson 1971) implied that the observations were probably initially related to disappearance

of the adults.

164. Several of the other benthic groups such as the chironomids, isopods, sphaerids, and harpacticoids displayed trends at many of the Disposal Sites that could only be related to some deviation from their life cycles following disposal. For example, two chironomids, Chironomus sp. and Procladius sp., observed in this area, based on their abundance patterns at the Reference Sites (Figures A35 and A60), probably emerged during July and August. This was similar to cycles reported elsewhere (Hilsenhoff 1966). Although occurring again at the Reference Sites in the fall after disposal, they were not present in the Disposal Site collections in similar numbers until more than 90 days after disposal (Figure A60). The benthic environment was still altered markedly as long as 30 days after disposal (14 September 1975). This was the period when chironomid oviposition probably occurred in this area (Hilsenhoff 1966). The larvae possibly did not inhabit the Disposal Sites and, consequently, any numbers observed later in the investigation probably were the result of migration from other areas. Thus, the populations were lower and may have directly affected the rest of the community, especially predators.

165. The following spring, when chironomid populations appeared to reach their maximum at the Reference Sites, the Disposal Site samples still showed much lower numbers, except for Procladius at D2. Either fewer numbers of these species were present at the Disposal Sites throughout the study or else something occurred in the physicochemical environment between the 16 November and 21 April sampling. Whichever factor was involved, the result was a decrease in either total number or in the frequency of larger organisms that would be retained on the seive mesh. Whatever the circumstance, the life cycle of this group was altered. This was an example of how the dredged material disposal possibly can impact the benthic community when disposal occurred during an important phase (i.e. reproduction) of a particular faunal life cycle.

166. As discussed above, the encystment phase of the harpacticoid's life cycle also appeared to be interrupted by disposal in

1975 (Figure A78). Consequently, the patterns observed for this group possibly were different at the Disposal Sites than observed at the Reference Sites. Normally, these organisms encyst after fall overturn and reproduced during the winter and early spring (Moore 1939, Dineen 1953). Possibly because of the interruption of encystment by disposal perturbations, the whole cycle appeared to be affected at the Disposal Sites and thus numbers remained low compared to the reference until the following summer, 8 July 1976 (Figure A77). The initial interference in the life cycle may have caused a lag in this species' abundance patterns. However, the latter was corrected by the following year.

167. In many instances, similar patterns as those described for the chironomids and harpacticoids also were evident for the sphaerids and isopods. Since the breeding period for many of these benthic forms occurs throughout much of the year (Baker 1928, Pennak 1953, Hilsenhoff 1966), the disposal operation may account for many of the impacts observed for specific organisms during this investigation.

168. Since the interruption of normal faunal life cycles appeared to be one of the more important biological results noted during this investigation, it is suggested that a need exists for future experimental studies to determine the actual (rather than implied) life history, changes, and interactions that result from disposal of dredged material in the open-water lacustrine environment. If these studies had been conducted during this investigation, the ecological relationships between community members, including recolonization after disposal, could have been more explicitly identified.

169. The fisheries aspect of this overall investigation is presented in Appendix A' of this report. Any general discussion of this component is done within the confines of Appendix A'. Specific relationships between the fisheries, the highest level of the aquatic trophic web, and impacts upon the invertebrate fauna from dredged material disposal, is discussed in the Evaluative Summary.

PART VII: SUMMARY AND CONCLUSIONS

170. The only measurable effects on the majority of pelagic biota were short-lived. There were possible decreases noted in pigment concentrations in the deeper waters that were assumed to be in response to disposal plumes moving just above the bottom substrate, down-current from disposal. Both stimulation and inhibition of primary producers were suggested from the bioassay results. Stimulation was observed on several occasions from small additions (0.1 mℓ) of elutriate water while inhibition occurred whenever volumes of 15.0 mℓ or greater were added. Evaluation of mixing and dilution factors involved in a disposal event is required to more fully predict the impact upon the phytoplankton. The results of the bioassays also suggest that the addition of detrital particles to the water column both directly from the disposal event and indirectly from resuspension of disposed material provides suitable surface areas for bacterial colonization. In turn, the biochemical oxygend demand of the area may be altered.

171. In addition to the increase in heterotrophic activity related to the detrital material from disposal, an initial response was noted by the crustacean zooplankton. Increases in numbers of the major zooplankton groups suggest the availability of a food source, either from stimulated phytoplankton production or more likely from increased concentrations of ammonia, an indicator of a detritovore-based food web. With time (30 to 60 days after disposal), the zooplankton collections suggest a possible adverse impact from disposal in the bottom waters. Population numbers appeared to decrease over the Disposal Sites, implying that the organisms were not concentrating as heavily and as close to the bottom at these sites in contrast to results from the Reference Sites. The release of toxic materials at the sediment-water interface may have caused zooplankton species to avoid the bottom waters in these areas. A year after disposal this trend was no longer observed. However, the changes in the zooplankton population collected may

have been more of a function of naturally occurring patchiness and not a result of disposal.

172. The impact on the benthic biota was more noticeable and appeared to be more long-term than for the pelagic organisms. There was an immediate alteration in community structure at the Center Disposal Sites. Foreign species (River and Harbor inhabitants) were able to displace resident Lake populations. Several resident Oligochaeta also were able to thrive in the altered habitats. A few other Oligochaeta (e.g., Aulodrilus) were limited in population numbers. Most surface fauna, other than the worms, disappeared from the Disposal Area. Some fauna living in deeper sediment layers and initially buried were not observed again in these layers until more than 30 days after the disposal event.

173. With disposal came the addition of species foreign to the Lake habitat plus the elimination of resident faunal groups other than the oligochaetes. There were corresponding increases in some population numbers. Larger species did not become reestablished in the deeper sediment layers 5 days after the disposal event. Consequently, trophic relationships were altered that subsequently could affect the food web in the immediate area.

174. The lack of diversity of the Center Disposal Sites was eventually reflected by sites not directly impacted by disposal. Initially, invasion by more mobile fauna (e.g., isopods) took place on sites adjacent to those receiving disposed material. This invasion initially altered the community structure on these sites. With time (30 days), several of the foreign species were observed inhabiting these same sites, suggesting an additional invasion from the Center Disposal Areas. The ease with which the nonresident species invasions occurred may have been related to the initial migration of resident species escaping burial. The resultant imbalance at the distant sites created possible instability and made the community more susceptible to invasion by foreign species. Some of these invaders from the dredged material such as L. udekemianus were able to maintain their population numbers as long as a year after the disposal

event.

175. The oligochaete genera Limnodrilus proved to be a good indicator of changed conditions in the Lake habitat, as has been observed in numerous other freshwater investigations. The ratio of this group to the genus Aulodrilus dramatically increased after disposal. Of the foreign species eluded to above, three belonged to the genus Limnodrilus and another species, L. hoffmeisteri, was the dominant mature organism observed at all Center Disposal Sites. In contrast, the reference samples exhibited more even abundances of Oligochaeta as well as other taxa.

176. Varied responses from disposal were observed for several of the other abundant benthic species. One chironomid (Chironomus sp.) population never returned to predisposal levels at the Center Disposal Sites, while Procladius sp. reappeared 30 days after disposal but decreased in numbers, compared to Reference Site levels, the following spring. The crustaceans, isopods, amphipods, and ostracods also exhibited varied responses to disposal. The isopods, one of the more mobile species, moved out of the Center Disposal Areas. The ostracods displayed increased abundance at the Disposal Sites, which was probably related to a species change. The amphipods, during their peak abundances in the nearshore waters, only occurred in moderate numbers at the disposal locations. Another crustacean group, the harpacticoids, exhibited a response possibly related to the fact that disposal coincided in time with an important phase of the organism's life cycle. Disposal in 1975 occurred during the encystment phase of this group's life cycle. However, by the following year the population that existed prior to disposal had been largely reestablished.

177. The long-term evaluation of disposal impact on the benthic environment indicated that recolonization was unpredictable. For example, the chironomids reappeared on the Center Disposal Sites but then decreased at these same sites the following spring, when increases in population numbers were occurring on the Reference Sites. Other groups such as the isopods displayed fluctuating patterns in population

numbers during the 1-year period after disposal. Because of these fluctuations and the lack of definitive knowledge concerning reproductive cycles of native organisms, it could only be assumed that the population changes were a result of possible instability within the community structure. The results further suggested that recolonization is a very complex process and could not be totally evaluated from this study.

178. Organisms more adapted to unstable bottom conditions survived disposal much better than others. Disposal caused a decrease in taxa other than annelids, but on the other hand, stimulated production of the remaining survivors. Sampling events in excess of 5 days after disposal displayed a decrease in species number that returned to predisposal levels within 1 year after disposal. Many worm species were present throughout the study, but all the other taxa occurred irregularly. The number of individuals also was similar to reference levels 1 year after disposal, but species composition was altered slightly.

179. The results of this study suggested:

a. Pelagic biota are only mildly impacted in the area of disposal and recovery is relatively rapid except possibly in the bottom waters directly influenced by dynamics at the mud-water interface. Zooplankton life cycles indicate that the fall and early spring would be undesirable periods for open-water disposal of dredged material.

b. The bottom area initially impacted by disposal is very limited and dependant upon the path and surface distance covered by the hopper dredge while disposing of dredged material. With time, however, invasions of communities some distance from the Disposal Sites by foreign species may take place, possibly as a result of unstable community structure.

c. An evaluation of the community structure of dredged material in contrast to the communities being disposed upon is very important. The types of organisms transported to the Disposal Sites within dredged material play a large role in restructuring the entire bottom community in the vicinity of disposal.

d. Since important components of the life cycle of many species encountered during this study occur at distinct

seasonal time intervals that rarely correspond to one another, disposal at any time will impact some component of the trophic food web. Consequently, a decision concerning the least harmful time intervals for disposal must be based upon minimal effects on the fauna directly related to the higher levels of the food web. Maximums in benthic organism numbers observed in early spring and late summer indicate these periods would definitely be unadvisable for disposal events.

e. The biota in freshwater open-lake disposal areas largely recovered as short as 1 year after disposal, but the community structures may be slightly altered in contrast with predisposal conditions.

180. The results of the fishery studies can be summarized as follows:

a. The impact of a disposal event on adult and young-of-the-year nektonic organisms is limited to a short-term avoidance of the physical disturbance. Mid-water and surface-dwelling species enter the plume created by the disposal event with little or no apparent avoidance. Bottom-dwelling species move from the Disposal Area to a location at least 300 m distant and return to the Disposal Site within a period of < 1 hr.

b. Long-term avoidance or attraction of nektonic organisms was not observed. It is probable that no response to the pile of dredged material can be documented.

c. Feeding behavior of offshore demersal species is based principally on chironomids, isopods, leeches, snails, and smaller fishes. A short-term effect was noticed at the Disposal Sites in that foreign species and disposed detritus were present in the Disposal Area fishes. It is probable, however, that these were fed upon merely because they were available, not because a feeding attraction was occurring. This effect was observed only for a short period of time.

d. Fish populations are highest in the Disposal Area during June-July and lowest during August. This would indicate that the least impact would be possible during late August through September.

e. Most spawning and nursery activity in the Ashtabula area is centered along the nearshore zones from the shoreline to the 7.5-m contour (about 1.6-3 km). Breakwall areas and protected waters such as marinas are highly productive. There is little or no use of mud substrates in offshore areas. Thus, disposal over mud substrates > 3 km offshore would have a minimal impact on fish production.

f. No changes in community structure or population size could be documented for offshore sites during postdisposal studies. Fish populations are highly mobile in the offshore areas, are foraging over large areas, and are not greatly impacted

by a limited area of disposed material.

g. Changes in meiobenthic, oligochaete, or bottom zooplanktonic populations have little direct effect on offshore nektonic populations. These offshore fishes feed only rarely on oligochaetes and only gizzardshad feed on bottom muds containing algae, meiobenthos, or zooplankton. Shad are indiscriminate feeders; thus, changes do not create any discernible effect.

h. Isopod and chironomid populations changed in the area of disposal, but no long-term change or shift could be ascertained in the feeding behavior of the fish fauna. However, the possibility of short-term toxic substance uptake by fish feeding in the Disposal Area should be considered.

i. Mortality of demersal fish eggs was 100% in areas within 250 m of the point of disposal. No effect of disposal on eggs > 1 mile from Disposal Sites was observed. The effect of suspended particles or toxic materials on fish larvae was not determined but should be considered to be a potential problem.

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AQUATIC DISPOSAL FIELD INVESTIGATIONS, ASHTABULA RIVER DISPOSAL--ETC(U)
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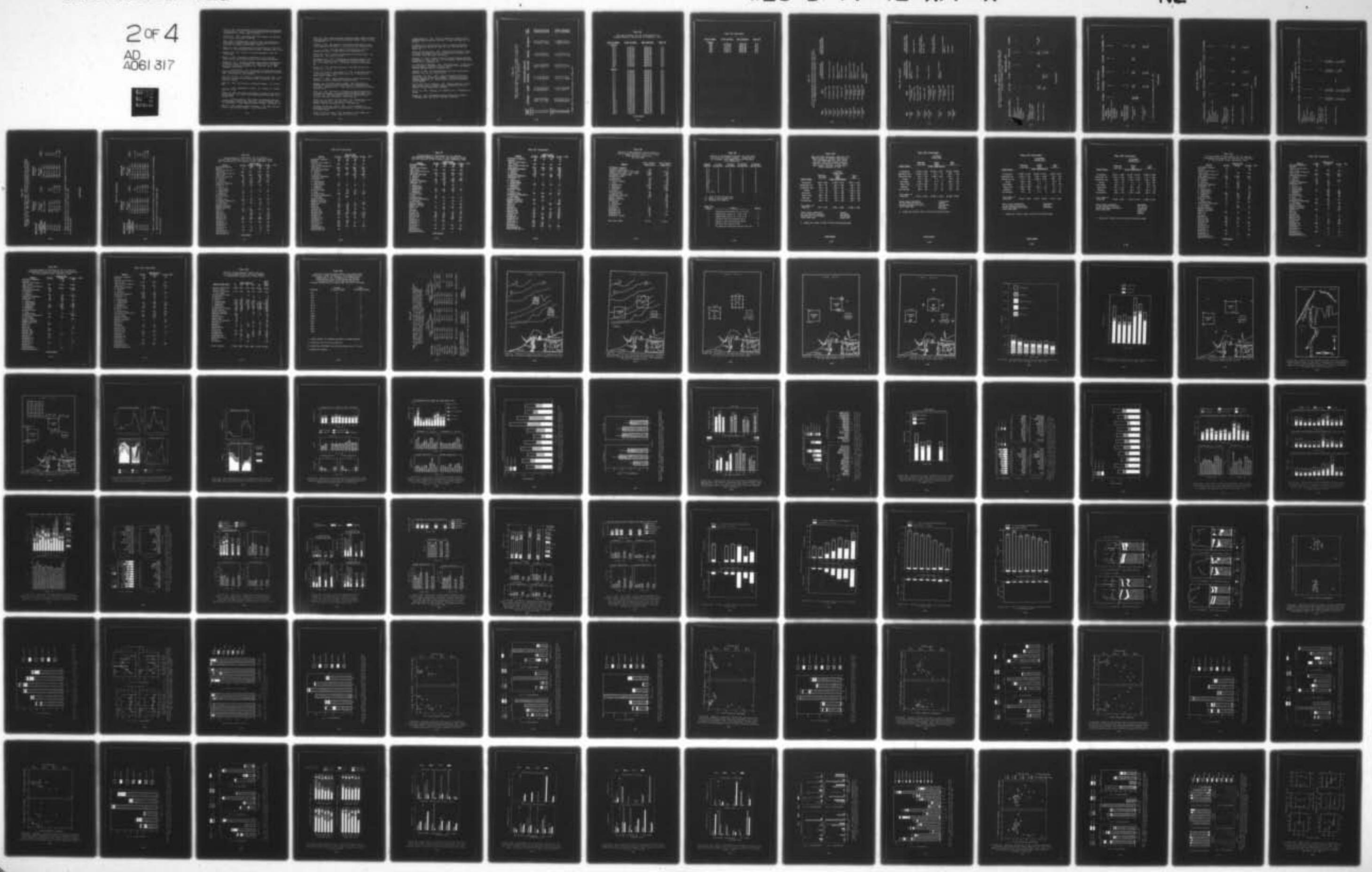

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TABLE A1

Major Group Composition and Total Number of Organisms Observed at the Initial Survey Stations (Figure A3) on 24 June 1975

Station Number	Percent Group Composition: Oligochaeta	Isopoda	Gastropoda	Sphaeriidae	Nematoda	Chironomidae	Total Number
Reference Area							
B 1	12.9	20.7	9.7	36.5	2.3	15.8	3288
B 2	40.8	14.9	7.1	15.5	7.3	11.4	4395
B 3	22.8	29.4	12.4	8.5	8.0	13.7	3440
B 4	1.9	53.2	13.0	7.7	4.6	10.7	2467
B 5	17.6	27.6	12.4	12.0	8.4	17.3	4253
B 6	1.8	15.2	33.5	28.6	6.0	7.8	4224
B 7	6.8	47.9	12.2	9.6	6.8	14.1	3336
B 8	26.8	23.2	13.9	4.8	1.6	20.4	2362
B 9	47.0	2.6	13.8	7.8	11.4	11.4	3960
Disposal Area							
B10	39.6	5.7	2.1	5.6	3.1	3.1	1815
B13	17.0	11.2	24.6	16.2	4.7	4.7	3383
B17	23.2	6.7	0.0	6.7	9.8	39.8	284
B18	64.2	5.2	11.3	6.5	1.0	10.8	4177
B21	70.6	1.5	17.3	2.3	1.9	3.7	7002
B22	45.2	22.6	7.1	4.7	3.5	15.1	2382
B24	55.6	3.8	13.0	11.9	1.0	13.4	2683
B25	32.2	8.9	28.2	9.1	5.4	16.1	3818
B26*	18.7	1.8	14.1	2.1	42.9	17.5	3081

* Sample taken from alternate disposal site (Figure A3)

TABLE A2

Site Descriptions for the Investigation of Dredged Material Deposition at Ashtabula, Ohio

Station Number	North Latitude	West Longitude	Depth (m)
Pelagic			
PW 1	41°56'55"	80°50'00"	17.5
PW 2	41°56'02"	80°50'00"	16.0
PW 3	41°57'46"	80°46'32"	16.0
PW 4	41°57'41"	80°46'09"	16.0
PW 5	41°56'53"	80°46'56"	15.0
PW 6	41°56'49"	80°46'31"	15.0
PW 7	41°57'43"	80°49'27"	17.0
PW 8	41°55'21"	80°48'46"	13.5
PW 9	41°55'21"	80°47'33"	13.0
PW10	41°56'13"	80°46'13"	14.0
PW11	41°57'46"	80°44'46"	16.0
NDS	41°57'46"	80°47'44"	16.0
Benthic			
C 1	41°56'55"	80°50'00"	17.5
C 2	41°56'53"	80°49'52"	17.5
C 3	41°56'02"	80°50'00"	16.0
C 4	41°56'00"	80°49'52"	16.0
D 1	41°57'48"	80°46'32"	16.0
D 2	41°57'46"	80°46'32"	16.0
D 3	41°57'44"	80°46'32"	16.0
D 4	41°57'46"	80°46'34"	16.0
D 5	41°57'46"	80°46'30"	16.0
D 6	41°57'41"	80°46'09"	16.0
D 7	41°56'54"	80°46'56"	15.0
D 8	41°56'53"	80°46'56"	15.0
D 9	41°56'52"	80°46'56"	15.0
D10	41°56'53"	80°46'58"	15.0
D11	41°56'53"	80°46'54"	15.0
D12	41°56'49"	80°46'31"	15.0
SD 1	41°57'51"	80°47'49"	16.0
SD 2	41°57'51"	80°47'44"	16.0
SD 3	41°57'51"	80°47'40"	16.0
SD 4	41°57'51"	80°47'36"	16.0
SD 5	41°57'48"	80°47'36"	16.0
SD 6	41°57'48"	80°47'40"	16.0
SD 7	41°57'48"	80°47'44"	16.0
SD 8	41°57'48"	80°47'49"	16.0
SD 9	41°57'44"	80°47'49"	16.0
SD10	41°57'44"	80°47'44"	16.0

(CONTINUED)

TABLE A2 (CONCLUDED)

Station Number	North Latitude	West Longitude	Depth (m)
Benthic			
SD11	41°57'44"	80°47'40"	16.0
SD12	41°57'44"	80°47'36"	16.0
SD13	41°57'41"	80°47'36"	16.0
SD14	41°57'41"	80°47'40"	16.0
SD15	41°57'41"	80°47'44"	16.0
SD16	41°57'41"	80°47'49"	16.0

Table A3

List of Sampling Dates in Relation to Disposal Event and Activities Conducted for Each Period During the Investigation of Dredged Material Deposition, Ashtabula, Ohio.

Date	Event	Long-Term (1975) Monitoring Activities	Short-Term (1976) Monitoring Activities
11-13 June 1975	Initial Survey		
24 June 1975	Predisposal 1975	Harbor and River Cores	
9-11 July 1975	Predisposal 1975	Pelagic sampling	
30-31 July 1975	Predisposal 1975	Pelagic and sediment sampling	
4-14 August 1975	Disposal 1975	Pelagic sampling	
14 August 1975	Post-disposal 1975 (hours)	Pelagic sampling	
19-20 August 1975	Post-disposal 1975 (5 days)	Pelagic and sediment sampling	
12-14 September 1975	Post-disposal 1975 (30 days)	Pelagic and sediment sampling	
19 October 1975	Post-disposal 1975 (60 days)	Pelagic sampling	
16-17 November 1975	Post-disposal 1975 (90 days)	Pelagic and sediment sampling	

(CONTINUED)

TABLE A3 (CONCLUDED)

Date	Event	Long-Term (1975) Monitoring Activities	Short-Term (1976) Monitoring Activities
21 April 1976	Post-disposal 1975 (8 months)	Pelagic and sediment sampling	
	Predisposal 1976		Pelagic Sampling
15-16 May 1976	Post-disposal 1975	Pelagic sampling	
	Predisposal 1976		Pelagic (Bioassays) and sediment sampling
24-26 May 1976	Disposal 1976		Harbor cores
10-11 June 1976	Post-disposal 1975 (10 months)	Pelagic sampling	
	Post-disposal 1976 (5 days)		Pelagic (Bioassays) and sediment sampling
7-8 July 1976	Post-disposal 1975 (11 months)	Pelagic and sediment sampling	
	Post-disposal 1976 (30 days)		Pelagic and sediment sampling
27 July 1976	Post-disposal 1976		Bioassays
14 September 1976	Post-disposal 1976		Bioassays

TABLE A4

Biological Variables Measured for Each Sampling Date and Site Sampled During the Investigation of Dredged Material Disposal, Ashtabula, Ohio

Biological Variable	11-13 June	24 June	9-11 July	30-31 July	13 August
	Sampling Dates, 1975				
P gic					
hytoplankton	x		x	x	
igments			x	x	x
Primary productivity (PPr)			x	x	
Zooplankton	x		x	x	
Elutriate-PPr					
Bioassay					
Benthic					
Macrobenthic fauna	x	x		x	
Meiobenthic fauna				x	
Core sectioning				x	
Pelagic sites sampled	SPW1-SPW7		PW1-PW11	PW1-PW11	PW1, PW3, PW5
Benthic sites sampled	B1-B26	Harbor and River		C1-C4, D1-D12	

(CONTINUED)

TABLE A4 (CONTINUED)

Biological Variable	14 August	19-20 August	12-14 September	19 October	16-17 November -1975
Pelagic					
Phytoplankton	X	X	X	X	X
Pigments	X	X	X	X	X
Primary Productivity (PPr)		X			X
Zooplankton	X	X	X	X	X
Elutriate-PPr Bioassay					
Benthic					
Macrobenthic fauna		X	X		X
Meiobenthic fauna		X			X
Core Sectioning		X	X		X
Pelagic Stations Sampled	PW1, PW2, PW3, PW5*	PW1- PW11	PW1- PW11	PW1- PW11	PW1- PW11
Benthic Stations Sampled		C1- C4, D1- D12	C1- C4, D1- D12		C1- C4, D1- D12

* Except for pigments which were measured at PW1 - PW11.

(CONTINUED)

TABLE A4 (CONTINUED)

Biological Variable	14 August	19-20 August	12-14 September	19 October	16-17 November
	Sampling Dates, 1975				
Pelagic					
Phytoplankton	x	x	x	x	x
Pigments	x	x	x	x	x
Primary productivity (PPr)		x			x
Zooplankton	x	x	x	x	x
Elutriate-PPr					
Bioassay					
Benthic					
Macrobenthic fauna		x	x		x
Meiobenthic fauna		x			x
Core sectioning		x	x		x
Pelagic sites sampled	PW1, PW2, PW3, PW5*	PW1-PW11	PW1-PW11	PW1-PW11	PW1-PW11
Benthic sites sampled		C1-C4, Di-D12	C1-C4, D1-D12		C1-C4, D1-D12

* Except for pigments measured at PW1 - PW11.

(CONTINUED)

TABLE A4 (CONCLUDED)

Biological Variable	21 April	15-16 May	24-26 May	10-11 June	7-8 July	27 July	14 September
			Sampling Dates, 1976				
Pelagic							
Phytoplankton	x	x		x	x		
Pigments	x	x		x	x		
Primary Productivity (PPr)	x	x		x	x		
Zooplankton	x	x		x	x		
Elutriate-PPr		x		x		x	x
Bioassay							
Benthic							
Macrobenthic fauna	x	x	x	x	x		
Meiobenthic fauna	x	x		x	x		
Core sectioning	x	x	x	x	x		
Pelagic sites sampled	PW1, PW2, PW3, PW5, NDS	PW1, PW2, PW3, PW5, NDS		PW1, PW2, PW3, PW5, NDS	PW1, PW2, PW3, PW5, NDS		
Benthic sites sampled	C1, C3, D2, D3, D8, D9	C1-C4, D2, D3, D8, D9, SD1-SD16, Harbor	SD10	C1-C4, SD1-SD16	C1-C4, D2, D8, SD1-SD16		

TABLE A5

Results of Four Elutriate-Primary Productivity Bioassays Conducted from May 1976 to September 1976. Results Corrected for Dark Bottle Uptake of ^{14}C. Any comparison $P < 0.05$ Considered Significant

	Bioassay #1		Bioassay #2	
ANOVA Results[a]	$P < 0.001$		$P < 0.01$	
Treatment (Elutriate Added)	Mean ± S.D. (cpm)	Sig.*	Mean ± S.D. (cpm)	Sig.*
Control (no additions)	1861.1 ± 229.1	-	6334.0 ± 591.4	-
0.1 ml			5611.6 ± 255.5	N.S.
1.0 ml	1691.2 ± 135.1	N.S.	6458.4 ± 869.3	N.S.
5.0 ml	1848.1 ± 97.1	N.S.	6473.2 ± 854.6	N.S.
10.0 ml	173.9 ± 53.3	$P < 0.001$	5788.5 ± 809.4	N.S.
15.0 ml	1094.0 ± 35.3	$P < 0.001$	4691.5 ± 1387.4	$P < 0.01$
25.0 ml	59.9 ± 16.8	$P < 0.001$	3799.3 ± 1679.2	$P < 0.001$

[a] Results of oneway analysis of variance on all treatments (Probability of similar means).

* Comparison between control and each treatment mean.

N.S. Not significant.

(CONTINUED)

TABLE A5 (CONCLUDED)

ANOVA Results[a]

Treatment (Elutriate Added)	Bioassay #3 ($P < 0.001$) Mean ± S.D. (cpm)	Sig.*	Bioassay #4 ($P < 0.001$) Mean ± S.D. (cpm)	Sig.*
Control (no additions)	21,567.2 ± 1,485.5	-	41,779.4 ± 3,192.6	-
0.1 ml	20,014.8 ± 1,363.1	N.S.	45,413.3 ± 1,943.5	$P < 0.04$
1.0 ml	19,254.8 ± 1,049.5	$P < 0.01$	40,506.2 + 4,011.3	N.S.
5.0 ml	19,102.3 ± 1,350.4	$P < 0.01$	41,122.8 ± 2,282.4	N.S.
10.0 ml	15,958.4 ± 733.1	$P < 0.001$	39,099.1 ± 3,916.3	N.S.
15.0 ml	13,730.6 ± 823.1	$P < 0.001$	37,170.0 ± 2,699.6	$P < 0.02$
25.0 ml	11,366.2 ± 1,259.6	$P < 0.001$	33,352.8 ± 1,373.5	$P < 0.001$

a Results of oneway analysis of variance on all treatments (probability of similar means).

* Comparison between control and each treatment mean.

N.S. Not significant.

TABLE A6

Average Number of Individuals for All Species
Encountered at Reference Site C1 for Each Sampling Period
Over the Duration of the Disposal Study, Ashtabula, Ohio

Species	Sampling Date			
	30 July	19 Aug.	14 Sept.	16 Nov. - 1975
Helobdella stagnalis	-	430	25	33
Naididae	50	314	596	166
Immature Tubificidae w hair setae	2393	2541	1123	924
Immature Tubificidae w/o hair setae	2921	3581	3520	2739
Aulodrilus americanus	66	-	199	297
A. limnobius	17	116	49	17
A. pigueti	17	17	25	33
A. pluriseta	462	1683	2047	2591
Ilyodrilus templetoni	33	33	-	-
Limnodrilus sp.	17	132	49	33
L. cervix	17	-	-	-
L. angustipenis	-	-	-	-
L. claparedianus	-	-	-	-
L. hoffmeisteri	66	50	74	363
L. maumeensis	50	-	-	-
L. udekemianus	-	-	-	-
Peloscolex ferox	33	17	-	17
P. freyi	-	-	-	-
P. multisetosus	215	479	723	247
Potamothrix moldaviensis	50	-	-	-
P. vejdovskyi	-	149	49	33
Tubifex tubifex	33	-	74	-
Manyunkia speciosa	-	-	-	-
Gammarus fasciatus	-	-	-	-
Asellus sp.	215	1271	574	149
Hydra sp.	50	116	-	-
Ostracoda	-	33	-	33
Valvata spp.	-	348	173	133
Amnicola spp.	-	17	-	50
Sphaerium spp.	116	199	298	50
Pisidium spp.	1089	3614	2746	1733
Alaimus sp.	-	-	-	-
Dorylaimus sp.	149	347	524	446
Laimydorus sp.	-	-	-	-
Turbellaria	-	-	-	50
Chironomus sp.	116	116	50	165
Tanytarsini	-	-	-	-
Procladius sp.	99	132	74	726
Dicrotendipes sp.	-	-	-	-
Microspectra sp.	-	-	-	-

(CONTINUED)

TABLE A6 (CONCLUDED)

Species	21 April	15 May	10 June	8 July - 1975
	Sampling Date			
Helobdella stagnalis	66	66	66	17
Naididae	50	165	99	34
Immature Tubificidae w hair setae	1007	363	429	347
Immature Tubificidae w/o hair setae	2904	4554	2046	1353
Aulodrilus americanus	215	594	269	314
A. limnobius	66	-	66	66
A. pigueti	-	99	66	17
A. pluriseta	2492	2343	2343	2096
Ilyodrilus templetoni	17	-	99	17
Limnodrilus sp.	-	-	33	17
L. cervix	-	-	-	-
L. angustipenis	-	-	-	-
L. claparedianus	17	-	-	-
L. hoffmeisteri	182	231	66	33
L. maumeensis	-	-	-	-
L. udekemianus	-	-	-	-
Peloscolex ferox	50	330	33	-
P. freyi	-	33	66	33
P. multisetosus	660	626	363	479
Potamothrix moldaviensis	17	-	-	-
P. vejdovskyi	-	1584	-	-
Tubifex tubifex	17	-	-	-
Manyunkia speciosa	33	-	-	-
Gammarus fasciatus	-	-	-	17
Asellus sp.	347	99	231	908
Hydra sp.	50	132	33	-
Ostracoda	165	66	-	-
Valvata spp.	-	198	99	66
Amnicola spp.	215	33	-	-
Sphaerium spp.	182	132	198	33
Pisidium spp.	2178	2244	2244	1320
Alaimus sp.	-	-	-	33
Dorylaimus sp.	479	858	264	215
Laimydorus sp.	-	-	-	-
Turbellaria	231	198	-	-
Chironomus sp.	314	396	132	17
Tanytarsini	66	-	-	-
Procladius sp.	1254	1221	891	363
Dicrotendipes sp.	-	-	-	-
Microspectra sp.	66	-	-	-

TABLE A7

Average Number of Individuals for All Species Encountered at Reference Site C3 for Each Sampling Period Over the Duration of the Disposal Study, Ashtabula, Ohio

	Sampling Date			
Species	30 July	19 Aug.	14 Sept.	16 Nov. - 1975
Helobdella stagnalis	33	17	50	231
Naididae	33	215	723	248
Immature Tubificidae w hair setae	1040	941	1448	545
Immature Tubificidae w/o hair setae	4703	5742	5792	3713
Aulodrilus americanus	50	116	324	314
A. limnobius	17	116	-	-
A. pigueti	-	83	50	132
A. pluriseta	2310	4241	4269	3366
Ilyodrilus templetoni	33	33	149	-
Limnodrilus sp.	33	99	-	-
L. cervix	-	66	100	-
L. angustipenis	-	-	-	-
L. claparedianus	-	-	50	-
L. hoffmeisteri	347	578	399	330
L. maumeensis	33	132	50	-
L. udekemianus	-	-	-	-
Peloscolex ferox	-	-	-	-
P. freyi	17	-	-	-
P. multisetosus	182	314	274	17
Potamothrix moldaviensis	-	-	-	-
P. vejdovskyi	-	17	50	33
Tubifex tubifex	17	-	-	-
Manyunkia speciosa	-	83	50	66
Gammarus fasciatus	-	-	-	-
Asellus sp.	33	578	448	248
Hydra sp.	-	50	-	-
Ostracoda	-	-	-	17
Valvata spp.	34	17	149	151
Amnicola spp.	83	50	50	83
Sphaerium spp.	50	132	50	-
Pisidium spp.	264	462	349	149
Alaimus sp.	-	-	424	-
Dorylaimus sp.	314	627	-	462
Laimydorus sp.	-	17	-	-
Turbellaria	-	-	-	-
Chironomus sp.	99	116	224	33
Tanytarsini	-	-	-	-
Procladius sp.	66	347	149	825
Dicrotendipes sp.	-	-	-	-
Cryptochironomus sp.	-	-	-	-

(CONTINUED)

TABLE A7 (CONCLUDED)

Species	Sampling Date 21 April	15 May	10 June	8 July - 1976
Helobdella stagnalis	99	33	99	44
Naididae	166	-	-	22
Immature Tubificidae w hair setae	660	231	165	418
Immature Tubificidae w/o hair setae	4257	4455	1716	3278
Aulodrilus americanus	512	165	198	660
A. limnobius	50	-	-	198
A. pigueti	33	-	-	66
A. pluriseta	2739	2706	429	1958
Ilyodrilus templetoni	50	-	198	22
Limnodrilus sp.	-	-	-	22
L. cervix	-	-	-	-
L. angustipenis	-	-	-	-
L. claparedianus	-	-	-	-
L. hoffmeisteri	248	264	132	32
L. maumeensis	-	-	-	-
L. udekemianus	-	-	-	-
Peloscolex ferox	-	-	-	110
P. freyi	-	-	-	-
P. multisetosus	661	495	297	264
Potamothrix moldaviensis	-	-	-	-
P. vejdovskyi	-	660	-	-
Tubifex tubifex	-	-	-	-
Manyunkia speciosa	446	165	-	88
Gammarus fasciatus	-	-	-	22
Asellus sp.	99	-	396	1298
Hydra sp.	-	-	-	-
Ostracoda	-	33	-	22
Valvata spp.	67	99	98	22
Amnicola spp.	117	-	-	44
Sphaerium spp.	67	-	33	88
Pisidium spp.	446	396	165	220
Alaimus sp.	17	-	33	44
Dorylaimus sp.	792	528	264	380
Laimydorus sp.	-	33	-	-
Turbellaria	776	-	-	-
Chironomus sp.	875	165	-	-
Tanytarsini	17	66	-	-
Procladius sp.	1254	1221	561	506
Dicrotendipes sp.	-	-	-	-
Cryptochironomus sp.	-	-	-	-

TABLE A8

Results of Macrobenthic Faunal Analysis for 16 Harbor Sampling Sites and 14 River Sampling Sites (Figure 9), 24 June 1975

Species	Harbor Stations (mean #/m²)	River Stations (mean #/m²)
Helobdella stagnalis	-	39
Ophidonais serpentina	104	-
Immature tubificidae w/o hair setae	8,044	15,743
Immature tubificidae w hair setae	1,899	592
Oligochaeta (unidentified)	3,867	3,196
Aulodrilus pigueti	-	79
A. pluriseta	138	69
Limnodrilus sp.	207	552
L. cervix (variant)	311	1,105
L. cervix	207	79
L. hoffmeisteri	2,247	9,582
L. maumeensis	1,036	1,312
L. udekemianus	138	1,065
L. spiralis	-	197
Peloscolex ferox	450	-
P. multisetosus	35	79
Potamothrix vejdovskyi	208	395
Tubifex tubifex	276	237
Gammarus fasciatus	-	237
Sphaerium sp.	-	474
S. lacustre	-	39
S. transversum	-	197
S. corneum	-	39
Pisidium sp.	242	39
Dorylaimus sp.	69	-
Chironomus sp.	483	39
Polypedilum sp.	35	-
Procladius sp.	35	158
Tanytarsini (Tribe)	35	-
Mean Total Number	24,754	41,911

TABLE A9

Results of Discriminant Analysis for Long-term Evaluation of (1975) disposal. Comparison of All Disposal Site Communities with Reference Site Communities

Disposal Stations	31 July (15 day Pre)	19 August (5 day Post)	14 September (30 day Post)	16 November (90 day Post)
D 1	4	1	2	2
D 2*	1	1	1	1
D 3	3	5	5	6
D 4	5	3	1	0
D 5	0	2	0	2
D 6	0	0	0	0
D 7	2	4	0	2
D 8**	2	2	2	2
D 9	5	0	0	0
D10	5	2	0	0
D11	2	3	2	0
D12	1	0	0	0
C 2	0	0	0	0
C 4	0	0	0	0
C 1, C3***	0	0	0	0

* Center of Harbor Disposal Area
** Center of River Disposal Area
*** Reference Site Community

Symbol Used Above	Meaning	Case No.
0	Similarity with Reference (P > 0.75) Site	1
1	Significantly similar (P > 0.95) to D2	2
2	Significantly similar (P > 0.95) to D8	3
3	Similarity with both Reference and D2	4
4	Similarity with both Reference and D8	4
5	Similarity with both D2 and D8	4
6	No significant similarity with any other site	4

TABLE A10

Mean and 95% Confidence Intervals for Major Groups of Benthic Macrofauna for the Reference (C1, C3), River Disposal (D2) and Harbor Disposal (D8) for Collections 15 Days Before and 5 Days, 30 Days, and 90 Days After Disposal in 1975

Faunal Group	31 July (15-Day Pre) Reference (C1, C3)	Harbor (D2) (total organisms/m²)	River (D8)
Oligochaeta	6516 ± 1953	11,022 ± 4,420	8,827 ± 3,331
Aulodrilus spp.	682 ± 347	992 ± 1,493	280 ± 203
Limnodrilus spp.	245 ± 126	1,369 ± 536	627 ± 413
Isopoda	132 ± 96	247 ± 320	1,105 ± 1,023
Gastropoda	18 ± 28	264 ± 388	198 ± 326
Sphaeriidae	603 ± 572	247 ± 252	264 ± 374
Nematoda	179 ± 143	132 ± 167	429 ± 464
Chironomidae	198 ± 123	66 ± 106	214 ± 87
Total Number of Organisms	7731 ± 2310	11,863 ± 5,086	11,088 ± 2,202

Faunal groups responsible for discrimination observed between Control and Disposal Sites (Table A9)*	Isopoda Gastrapoda Chironomidae Sphaeriidae

* Groups are listed in order of most discriminating power.

(CONTINUED)

Table A10 (Continued)

Faunal Group	Reference (C1, C3)	Harbor (D2)	River (D8)
	19 August (5-Day Post)		
	(total organisms/m²)		
Oligochaeta	11,022 ± 3,395	20,443 ± 3,273	25,036 ± 18,974
Aulodrilus spp.	3,309 ± 1,210	82 ± 87	902 ± 252
Limnodrilus spp.	643 ± 267	4,389 ± 1,913	1,650 ± 437
Isopoda	716 ± 353	0 ± 0	66 ± 121
Gastropoda	239 ± 168	0 ± 0	264 ± 363
Sphaeriidae	2,219 ± 1,603	16 ± 46	176 ± 370
Nematoda	421 ± 201	0 ± 0	66 ± 121
Chironomidae	355 ± 205	16 ± 46	44 ± 140
Total Number of Organisms	15,642 ± 4,325	20,526 ± 3,356	25,696 ± 18,981

Faunal groups responsible for discrimination observed between Reference and Disposal Sites (Table A9)*	Oligochaetes Isopoda Chironomidae Nematoda Gastrapoda

* Groups are listed in order of most discriminating power.

(CONTINUED)

TABLE A10 (CONTINUED)

Faunal Group	Reference (C1, C3)	Harbor (D2)	River (D8)
	14 September (30-Day Post)		
	(total organisms/m^2)		
Oligochaeta	10,994 ± 2,356	37,657 ± 16,571	2,955 ± 1,679
Aulodrilus spp.	3,577 ± 1,124	1,957 ± 2,468	90 ± 130
Limnodrilus spp.	610 ± 364	2,865 ± 2,755	583 ± 620
Isopoda	459 ± 228	0 ± 0	18 ± 51
Gastropoda	331 ± 199	0 ± 0	93 ± 196
Sphaeriidae	1,507 ± 1,268	109 ± 135	0 ± 0
Nematoda	426 ± 182	18 ± 51	16 ± 45
Chironomidae	176 ± 79	0 ± 0	109 ± 181
Total Number of Organisms	14,162 ± 1,838	37,857 16,572	4,212 ± 1,202
Faunal groups responsible for discrimination observed between Reference and Disposal Sites (Table A9)*		Oligochaeta Nematoda Gastrapoda	

* Groups are listed in order of most discriminating power.

(CONTINUED)

TABLE A10 (CONCLUDED)

Faunal Group	Reference (C1, C3)	Harbor (D2)	River (D8)
	16 November (90-Day Post) (total organisms/m²)		
Oligochaeta	8,272 ± 2,080	29,106 ± 26,475	12,860 ± 5,408
Aulodrilus spp.	3,542 ± 1,136	1,606 ± 3,432	1,171 ± 1,485
Limnodrilus spp.	396 ± 138	3,190 ± 4,225	1,303 ± 920
Isopoda	176 ± 107	0 ± 0	165 ± 284
Gastropoda	264 ± 42	22 ± 70	99 ± 159
Sphaeriidae	1,177 ± 1,113	374 ± 877	16 ± 45
Nematoda	451 ± 275	66 ± 121	363 ± 118
Chironomidae	979 ± 255	1,188 ± 2,708	379 ± 576
Total Number of Organisms	11,539 ± 2,502	3,328 ± 24,770	13,965 ± 6,139

Faunal groups responsible for discrimination observed between Reference and Disposal Sites (Table A9)*	Gastropoda Chironomidae Oligochaeta Sphaeriidae Isopoda Nematoda

* Groups are listed in order of most discriminating power.

Table A11

Average Number of Individuals for All Species Encountered at Disposal Site D8 Over the Duration of the Disposal Study, Ashtabula, Ohio

Species	Sampling Date 30 July	19 Aug	14 Sept -1975
Helobdella stagnalis	50	-	25
Naididae	17	-	25
Immature Tubificidae w hair setae	116	792	199
Immature Tubificidae w/o hair setae	7458	16,698	1922
Aulodrilus americanus	116	347	49
A. limnobius	33	-	
A. pigueti	-	116	-
A. pluriseta	132	264	-
Ilyodrilus templetoni	-	83	-
Limnodrilus sp.	33	248	50
L. cervix	-	67	99
L. angustipenis	-	-	
L. claparedianus	-	-	25
L. hoffmeisteri	281	561	74
L. maumeensis	198	297	25
L. udekemianus	-	99	124
Peloscolex ferox	198	33	174
P. freyi	-	-	
P. multisetosus	116	413	374
Potamothrix moldaviensis	-	-	-
P. vejdovskyi	17	116	-
Tubifex tubifex	-	149	49
Manyunkia speciosa	-	-	
Gammarus fasciatus	-	-	
Asellus sp.	1106	50	25
Hydra sp.	-	-	-
Ostracoda	-	-	-
Valvata spp.	150	67	49
Amnicola spp.	50	33	-
Sphaerium spp.	17	-	-
Pisidium spp.	248	132	598
Alaimus sp.	17	-	-
Dorylaimus sp.	413	33	50
Laimydorus sp.	-	-	-
Turbellaria	-	-	99
Chironomus sp.	165	-	-
Tanytarsini	-	-	-
Procladius sp.	50	17	199
Dicrotendipes sp.	-	-	-
Cryptochironomus sp.	-	-	-

(CONTINUED)

Table A11 (Concluded)

Species	16 Nov	21 April	8 July - 1976
		Sampling Date	
Helobdella stagnalis	66	-	17
Naididae	50	-	-
Immature Tubificidae w hair setae	875	396	182
Immature Tubificidae w/o hair setae	8554	9587	5924
Aulodrilus americanus	165	83	578
A. limnobius	-	-	-
A. pigueti	66	-	-
A. pluriseta	941	165	2739
Ilyodrilus templetoni	50	314	-
Limnodrilus sp.	116	99	-
L. cervix	-	50	-
L. angustipenis	-	-	-
L. claparedianus	-	99	-
L. hoffmeisteri	710	1320	660
L. maumeenis	-	66	495
L. udekemianus	-	363	83
Peloscolex ferox	-	66	50
P. freyi	-	-	
P. multisetosus	155	182	314
Potamothrix moldaviensis	-	33	-
P. vejdovskyi	693	17	198
Tubifex tubifex	-	347	-
Manyunkia speciosa	-	-	34
Gammarus fasciatus	-	33	33
Asellus sp.	155	-	941
Hydra sp.	-	-	-
Ostracoda	-	-	-
Valvata spp.	-	17	-
Amnicola spp.	83	-	51
Sphaerium spp.	-	-	-
Pisidium spp.	17	83	83
Alaimus sp.	-	17	17
Dorylaimus sp.	363	83	380
Laimydorus sp.	-	-	-
Turbellaria	17	-	-
Chironomus sp.	17	66	-
Tanytarsini	-	-	-
Procladius sp.	363	17	50
Dicrotendipes sp.	-	-	-
Cryptochironomus sp.	-	17	17

TABLE A12

Average Number of Individuals for All Species Encountered at Disposal Site D2 Over the Duration of the Disposal Study, Ashtabula, Ohio

Species	30 July	Sampling Date 19 Aug	14 Sept - 1975
Helobdella stagnalis	-	17	25
Naididae	-	35	-
Immature Tubificidae w hair setae	1007	3,333	4,843
Immature Tubificidae w/o hair setae	7260	12,045	23,992
Aulodrilus americanus	33	-	175
A. limnobius	83	-	-
A. pigueti	-	-	-
A. pluriseta	891	83	2,172
Ilyodrilus templetoni	17	231	125
Limnodrilus sp.	99	347	-
L. cervix	116	248	125
L. angustipenis	-	-	-
L. claparedianus	-	198	175
L. hoffmeisteri	578	1,634	1,498
L. maumeensis	380	809	199
L. udekemianus	-	66	-
Peloscolex ferox	-	-	77
P. freyi	-	-	-
P. multisetosus	199	73	2,521
Potamothrix moldaviensis	-	-	499
P. vejdovskyi	165	66	-
Tubifex tubifex	-	-	175
Manyunkia speciosa	-	-	-
Gammarus fasciatus	-	-	-
Asellus sp.	248	-	-
Hydra sp.	-	-	-
Ostracoda	-	-	25
Valvata spp.	100	-	-
Amnicola spp.	50	-	-
Sphaerium spp.	-	-	25
Pisidium spp.	232	33	-
Alaimus sp.	17	-	-
Dorylaimus sp.	116	-	-
Laimydorus sp.	-	-	-
Turbellaria	-	-	25
Chironomus sp.	50	-	-
Tanytarsini	-	-	-
Procladius sp.	-	-	-
Dicrotendipes sp.	-	17	-
Cryptochironomus sp.	-	-	-

(CONTINUED)

TABLE A12 (CONCLUDED)

Species	16 Nov	Sampling Date 21 April	8 July -1976
Helobdella stagnalis	33	165	66
Naididae	88	-	-
Immature tubificidae W hair setae	4,340	5808	512
Immature tubificidae w/o hair setae	11,286	9752	2904
Aulodrilus americanus	99	50	33
A. limnobius	17	-	-
A. pigueti	-	17	-
A. pluriseta	1,106	792	264
Ilyodrilus templetoni	528	594	-
Limnodrilus sp.	198	50	17
L. cervix	248	83	17
L. angustipenis	-	-	-
L. claparedianus	-	66	-
L. hoffmeisteri	594	858	627
L. maumeenis	17	33	149
L. udekemianus	132	363	17
Peloscolex ferox	363	413	132
P. freyi	-	-	-
P. multisetosus	1,337	875	182
Potamothrix moldaviensis	-	99	231
P. vejdovskyi	297	429	347
Tubifex tubifex	182	429	-
Manyunkia speciosa	-	17	-
Gammarus fasciatus	17	-	116
Asellus sp.	-	-	166
Hydra sp.	-	-	-
Ostracoda	33	66	-
Valvata spp.	17	33	50
Amnicola spp.	-	-	-
Sphaerium spp.	-	17	-
Pisidium spp.	264	627	17
Alaimus sp.	17	-	-
Dorylaimus sp.	33	132	-
Laimydorus sp.	-	-	-
Turbellaria	-	17	-
Chironomus sp.	132	50	-
Tanytarsini	-	-	-
Procladius sp.	1,106	1287	182
Dicrotendipes sp.	-	-	-
Cryptochironomus sp.	-	-	-

Table A13

Results of Macrobenthic Faunal Analysis for Five Ashtabula River Stations Sampled in Replicate (Figure A9), 15 May 1976

Species (mean #/m²)	River Stations E1	E2	E3	E4	E5	Group Mean Total
Immature Tubificidae w/o hair setae	6,963	3201	5,610	2607	23,892	8,455
Immature Tubificidae w hair setae	1,221	693	792	561	1,782	1,010
Aulodrilus americanus	-	-	33	-	-	7
A. pluriseta	-	-	-	66	-	13
Limnodrilus sp.	-	33	-	-	-	7
L. cervix	1,025	495	1,683	99	-	660
L. claparedianus	363	396	2,673	1056	1,188	1,135
L. hoffmeisteri	3,762	3531	5,181	1221	10,725	4,884
L. maumeensis	363	198	396	264	2,376	719
L. udekemianus	165	66	33	264	7,689	1,643
Potamothrix vejdovskyi	363	198	594	66	1,188	482
Tubifex tubifex	693	297	-	-	-	198
Manyunkia speciosa	-	-	-	33	-	7
Gammarus fasciatus	297	-	-	33	33	73
Ostracoda	132	-	-	-	-	26
Valvata lewisi	33	-	-	-	-	7
Sphaeriidae	33	-	-	-	-	7
Sphaerium transversum	33	-	-	-	-	26
Pisidium sp.	33	-	-	66	33	13
Nematoda	-	-	33	-	33	13
Alaimus sp.	33	33	66	99	-	46
Dorylaimus sp.	-	-	-	-	33	7
Thornia sp.	-	33	-	-	-	7
Turbellaria	165	33	-	33	66	59
Chironomidae	-	-	-	66	66	26
Procladius sp.	264	132	99	66	231	158
Orthocladiinae	-	33	198	33	-	53
Cardiocladius sp.	-	-	33	-	-	7
Diptera	-	33	-	-	-	7
Collembola	-	-	99	-	-	20
Total Organisms	15,939	9405	17,523	6633	51,150	20,130

Table A14

Results of Discriminant Analysis for Short-Term Evaluation (1976) of Disposal of Dredged Material. Comparison of All Disposal Site Communities with Reference Sites to Determine Any Change from the Disposal Event and Any Return to Reference Conditions of Those Sites Initially Affected

Quadrant	10 June (5 days after)	8 July (30 days after)
SD 1	0	1
SD 2	1	1
SD 3	0	1
SD 4	1	1
SD 5	1	-
SD 6*	0	0
SD 7*	0	0
SD 8	1	1
SD 9	1	1
SD10*	0	0
SD11*	0	0
SD12	-	-
SD13	-	-
SD14	-	-
SD15	0	1
SD16	1	1

* Center quadrats for disposal operation of dredged material.

1 = Similarity with reference communities.

0 = Significant difference from reference communities ($P < 0.05$).

- = Quadrat not sampled.

TABLE A15

Mean and Standard Deviations for Major Groups of Benthic Macrofauna for the Reference Sites (C1-C4) and the Center Disposal Quadrats (D6, D7, D10, D11) for Collections 5 Days and 30 Days After Disposal in 1976. Also Shown are the Faunal Groups that Contributed the Most to Significant Differences Observed from the Discriminant Analysis (Table A14) of the Reference and Disposal Sites

Faunal Group	10 June (5 days after) Control	10 June (5 days after) Disposal	8 July (30 days after) Control	8 July (30 days after) Disposal
	(total organisms/m^2)		(total organisms/m^2)	
Oligochaeta	3925.0 ± 1736.6	34,404.3 ± 22,156.7	5300.8 ± 1623.1	50,421.5 ± 19,334.9
Aulodrilus spp.	1384.5 ± 946.6	242.5 ± 247.6	2449.0 ± 963.5	855.0 ± 957.6
Limnodrilus spp.	104.3 ± 49.4	6,827.3 ± 3,569.5	96.5 ± 85.2	8,912.8 ± 1,260.3
Isopoda	456.3 ± 188.3	34.0 ± 27.1	969.5 ± 302.8	0
Gastropoda	176.0 ± 82.6	44.3 ± 33.5	100.5 ± 38.1	0
Sphaeriidae	1482.5 ± 1224.7	347.5 ± 234.6	860.8 ± 689.4	211.3 ± 147.3
Nematoda	374.0 ± 132.9	183.3 ± 121.3	467.8 ± 260.7	122.8 ± 41.8
Chironomidae	916.8 ± 220.5	257.5 ± 141.2	595.5 ± 331.7	36.0 ± 28.6
Total Number of Organisms	7427.8 ± 2343.2	35,520.5 ± 22,538.7	8362.8 ± 1582.9	50,835.8 ± 19,463.3
Faunal groups responsible for discrimination observed between reference and disposal sites (Table A14).	*Limnodrilus* spp. Chironomidae *Aulodrilus* spp.		Isopoda Oligochaeta *Limnodrilus* ssp.	

* Groups listed in order of most discriminating power.

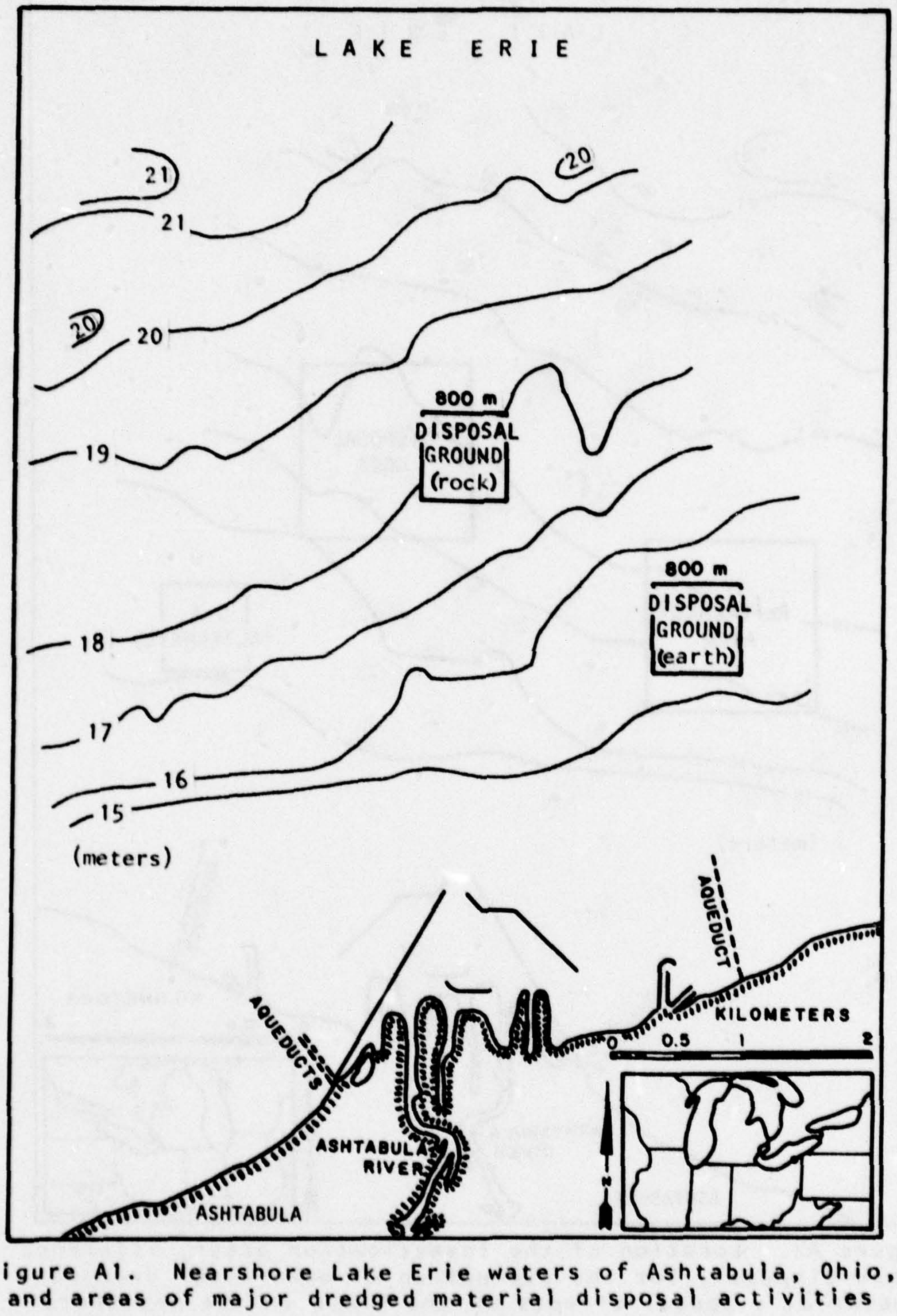

Figure A1. Nearshore Lake Erie waters of Ashtabula, Ohio, and areas of major dredged material disposal activities

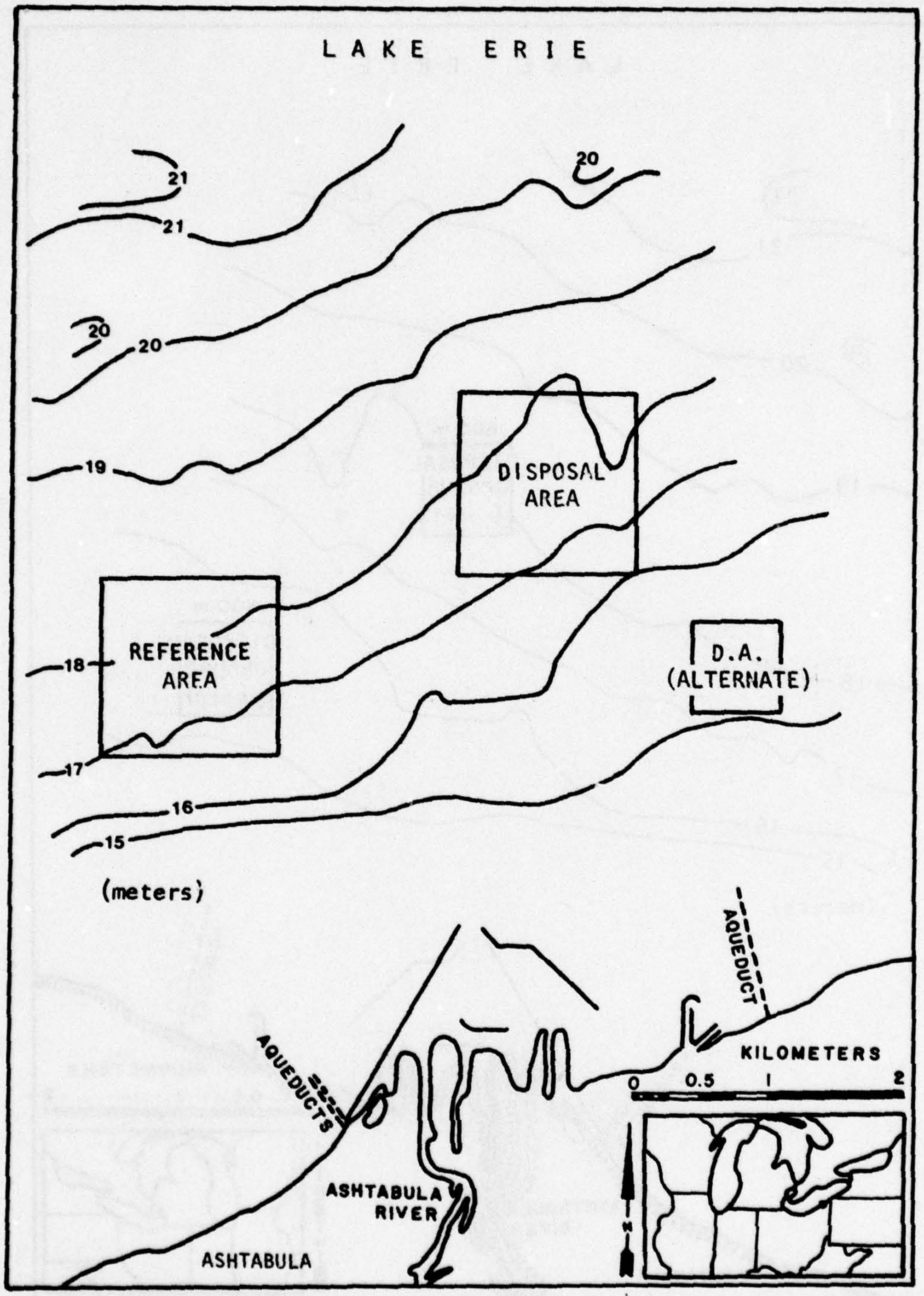

Figure A2. Location of the investigation areas, reference and disposal, for the evaluation of open-water dredged material disposal effects on the biota in the nearshore waters of Ashtabula, Ohio

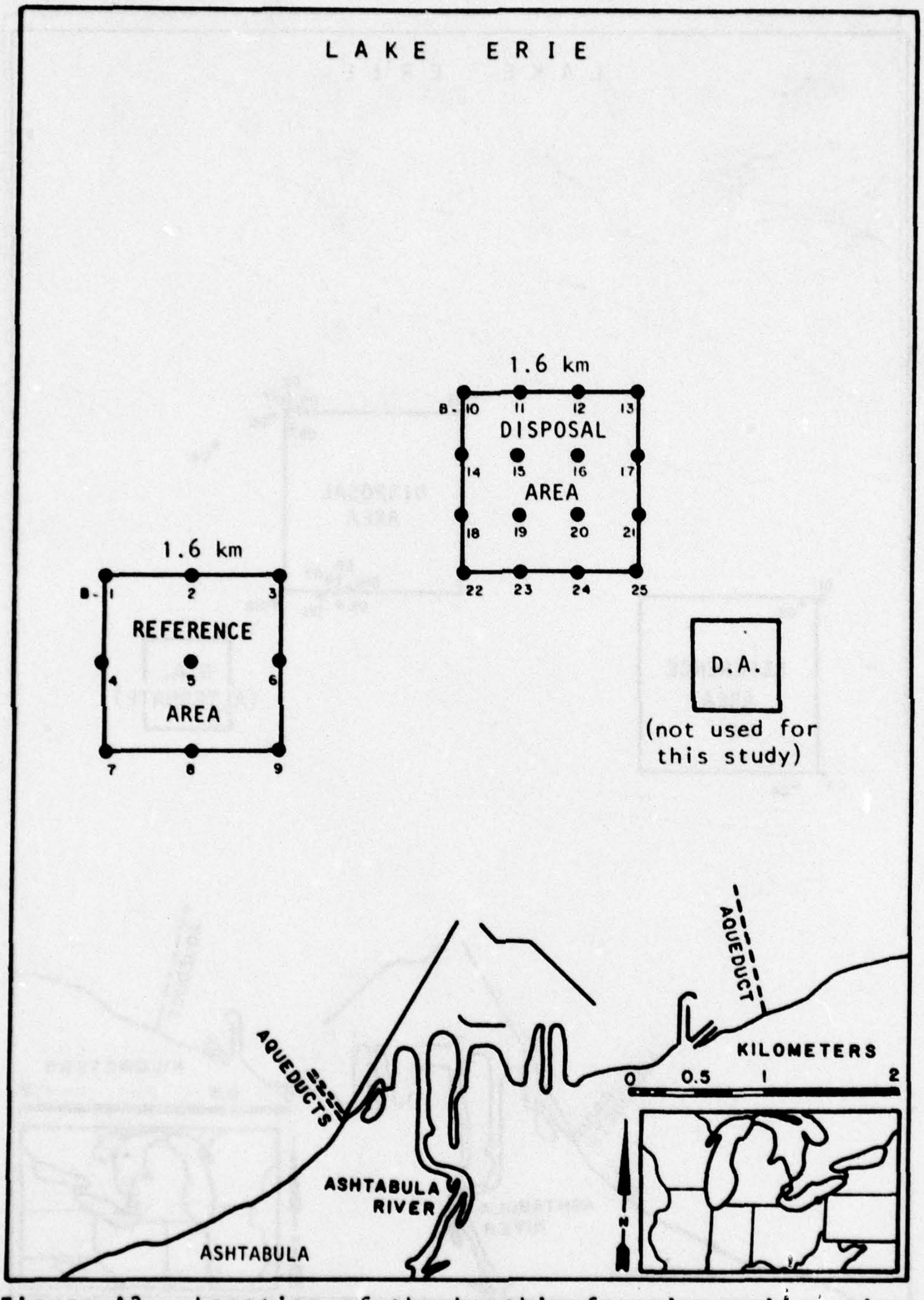

Figure A3. Location of the benthic faunal sampling sites for the initial survey (24 June 1975)

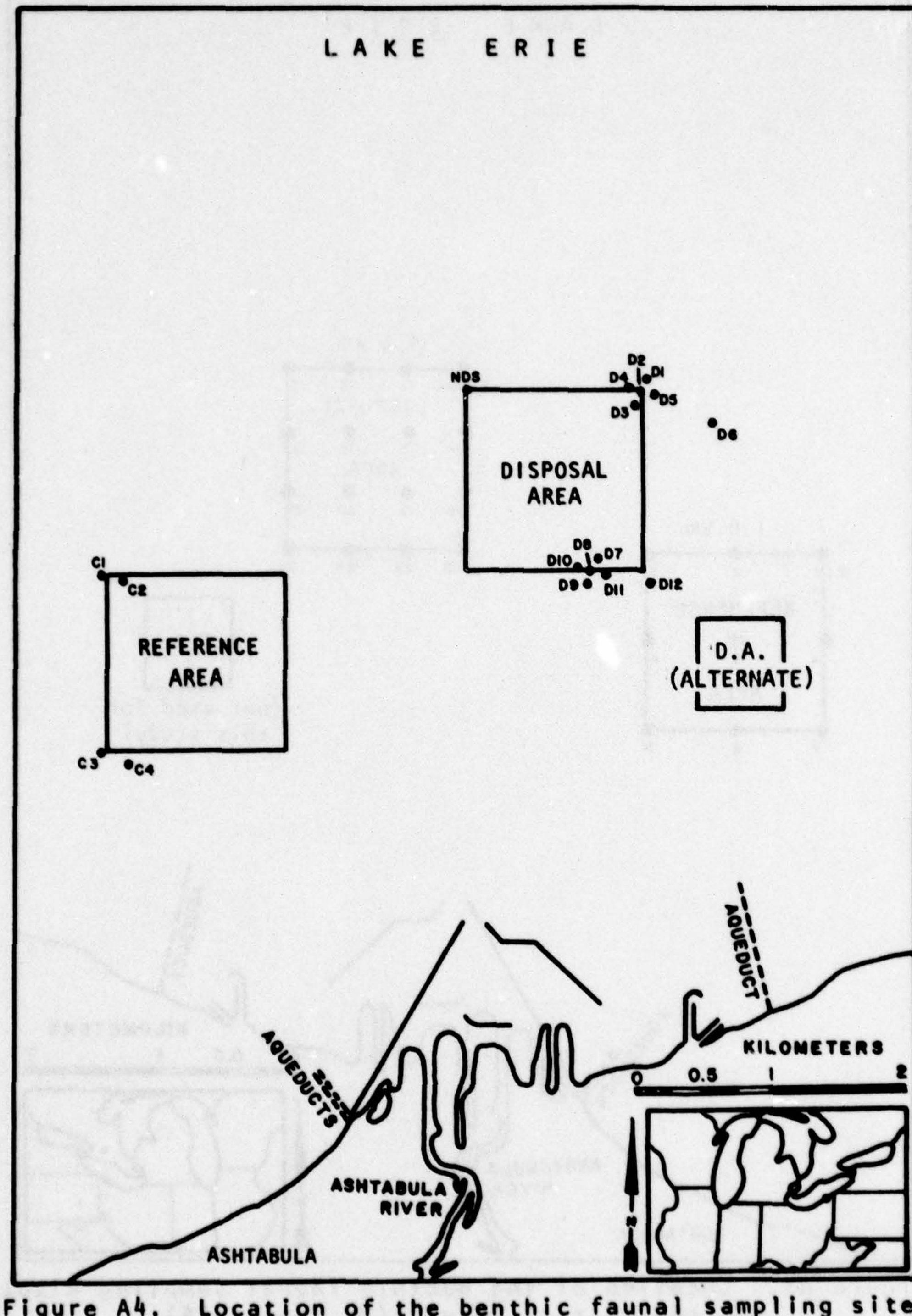

Figure A4. Location of the benthic faunal sampling sites for the 1975 disposal study

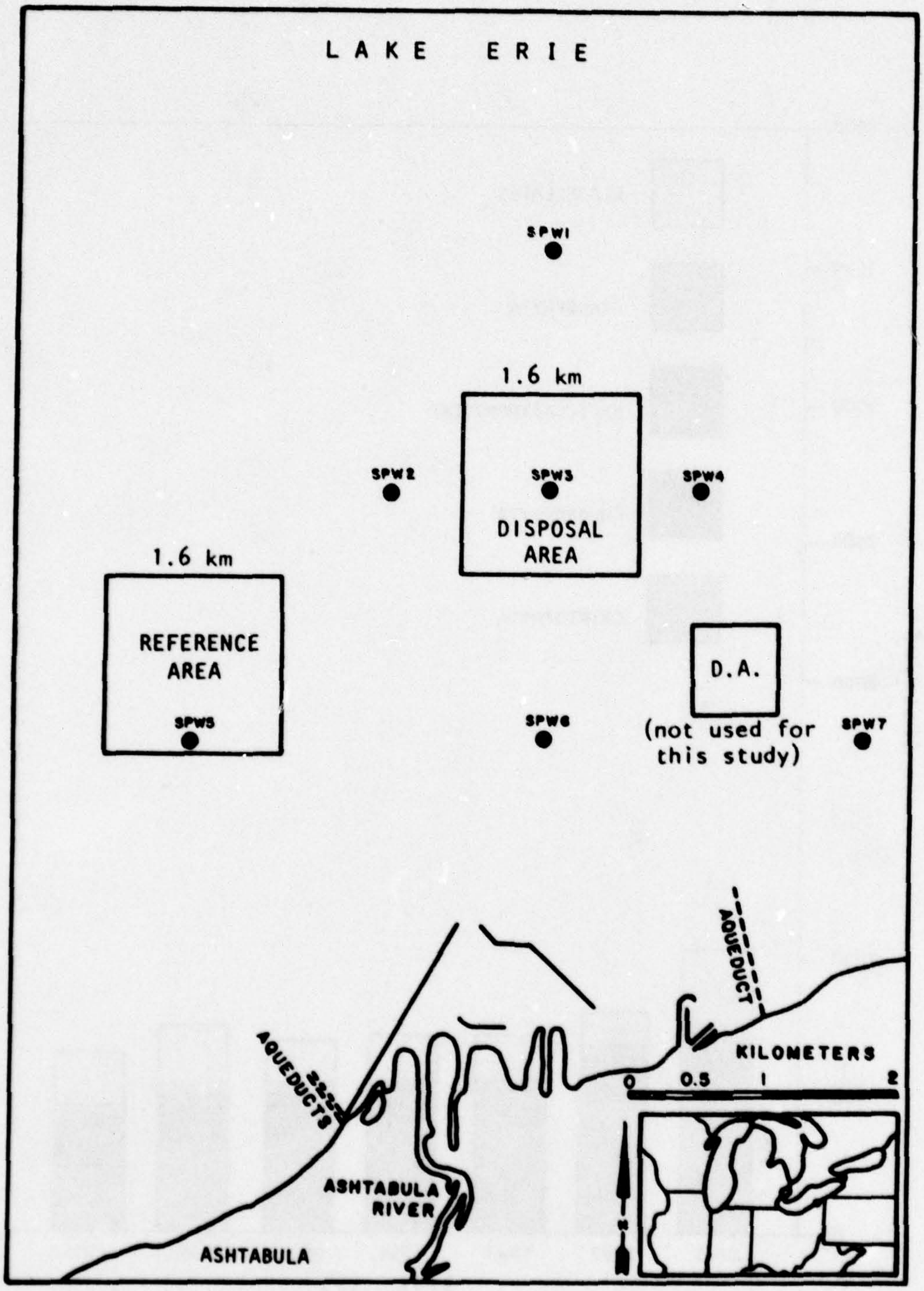

Figure A5. Location of the pelagic sampling sites for the initial survey (11-13 June 1975)

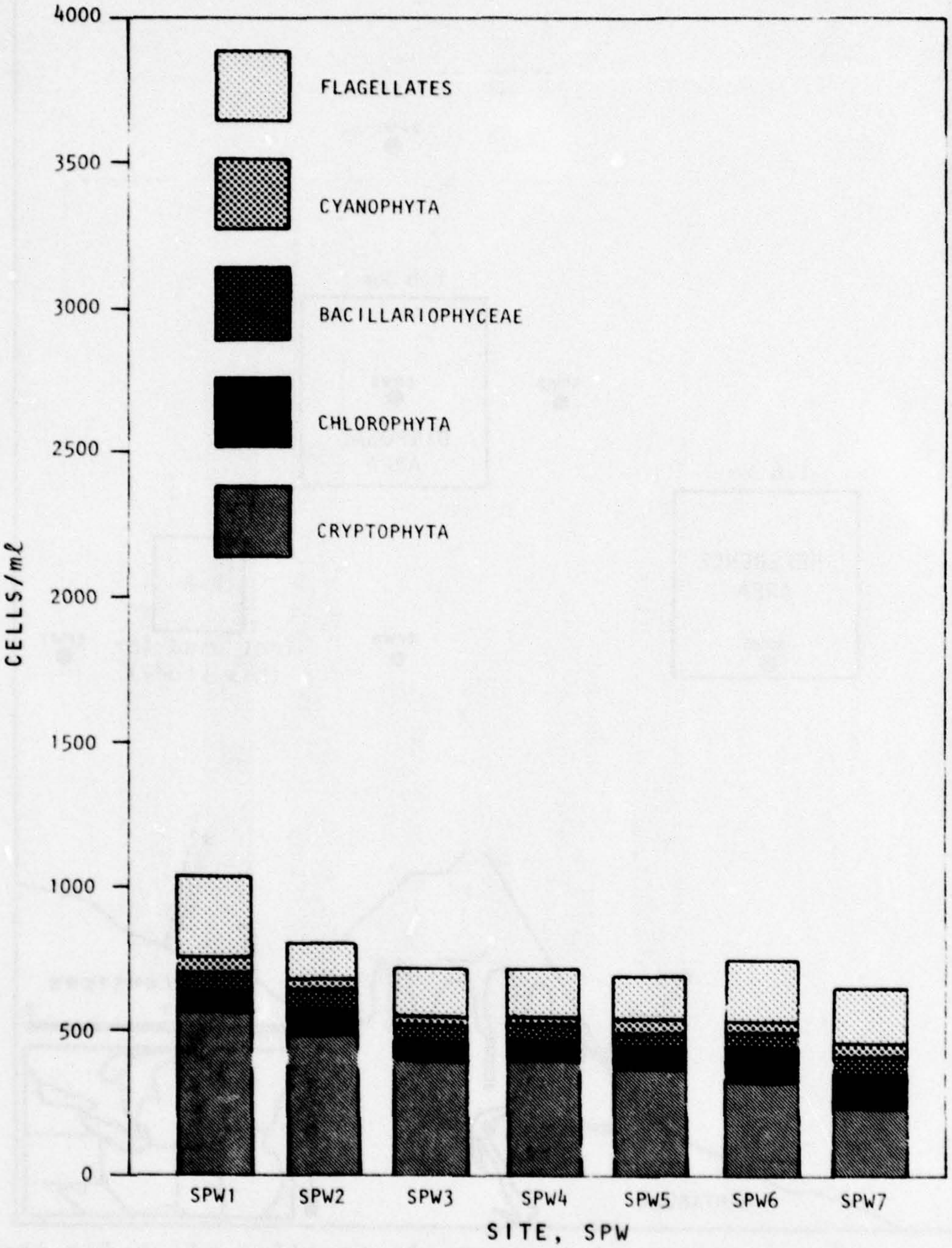

Figure A6. Phytoplankton composition by major taxonomic group for the initial survey (11-13 June 1975)

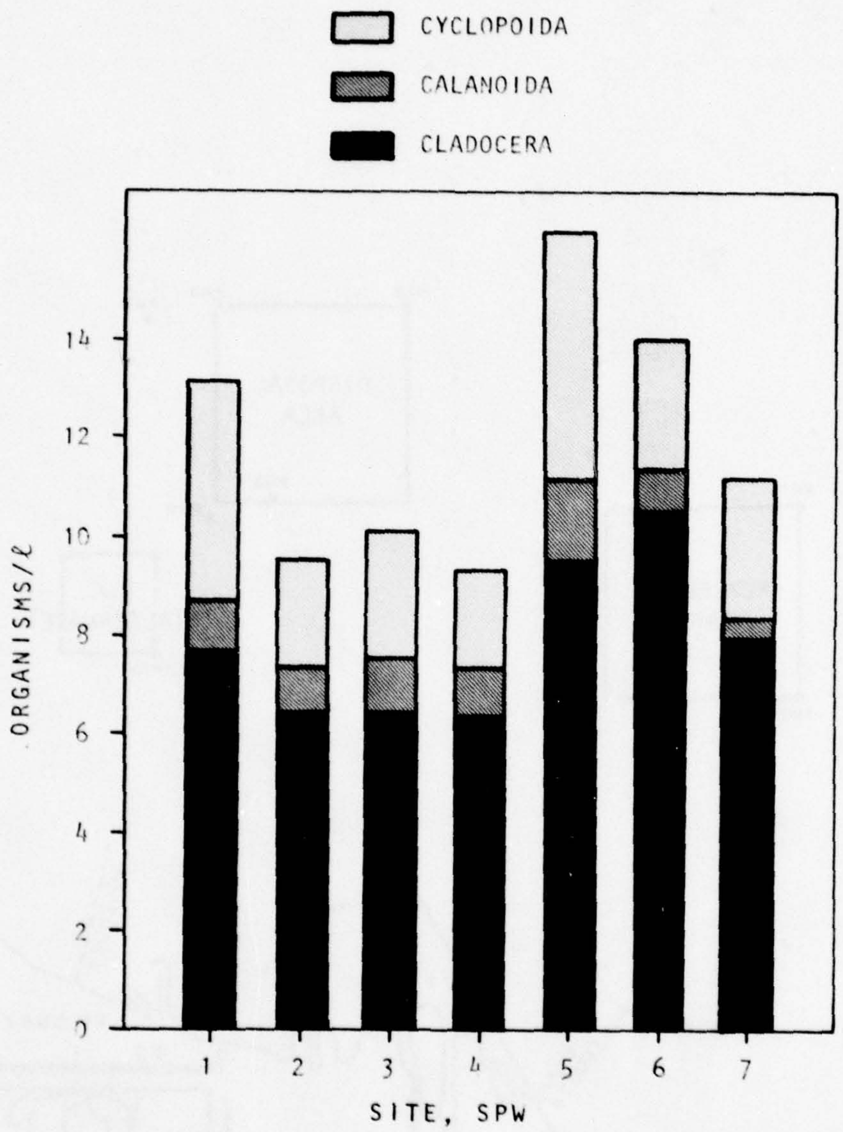

Figure A7. Zooplankton composition by major taxonomic group for the initial survey (11-13 June 1975)

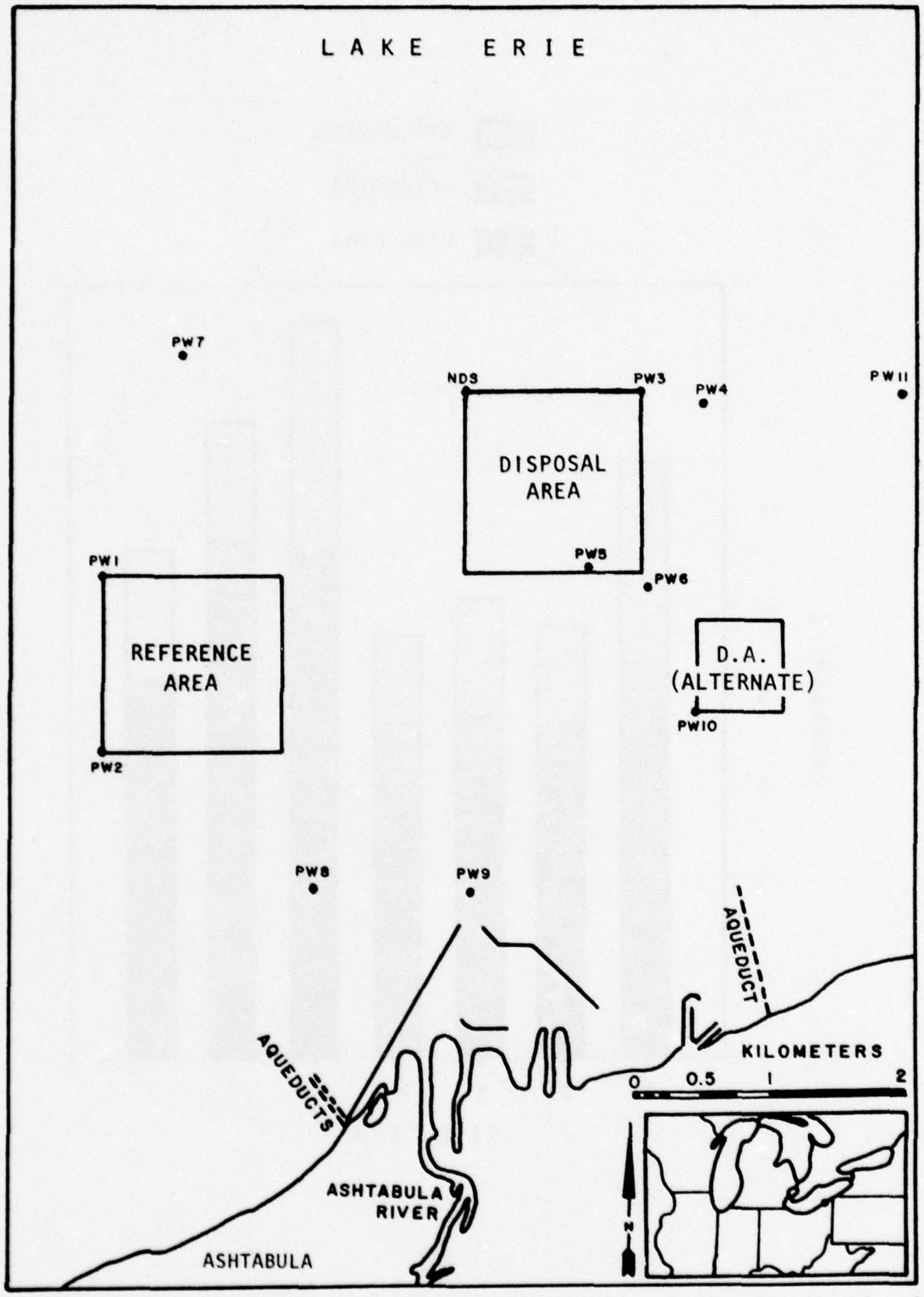

Figure A8. Location of pelagic sampling sites for both the 1975 and 1976 disposal studies

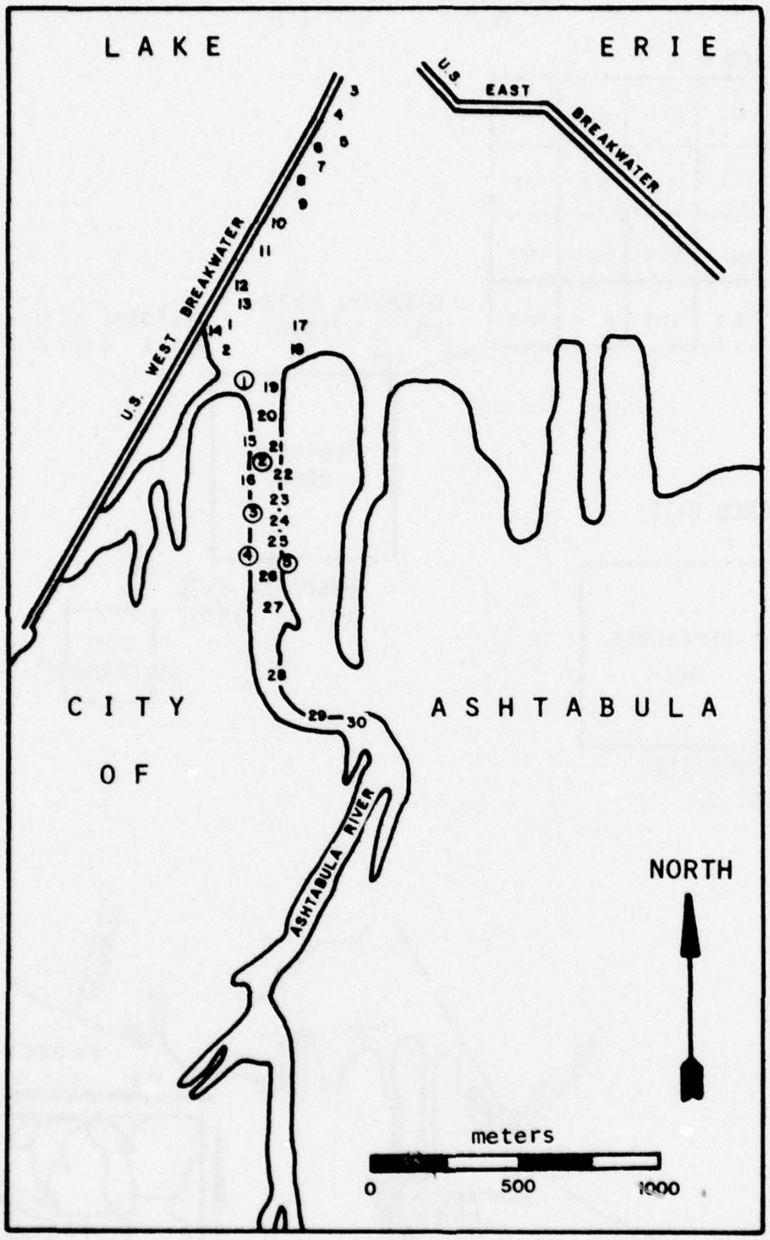

Figure A9. Location of the Ashtabula Harbor and River benthic faunal samples taken in 1975 prior to dredging and the Ashtabula River benthic faunal samples taken in 1976 prior to dredging. Numbers represent 1975 sampling locations, and circled numbers represent 1976 sampling locations

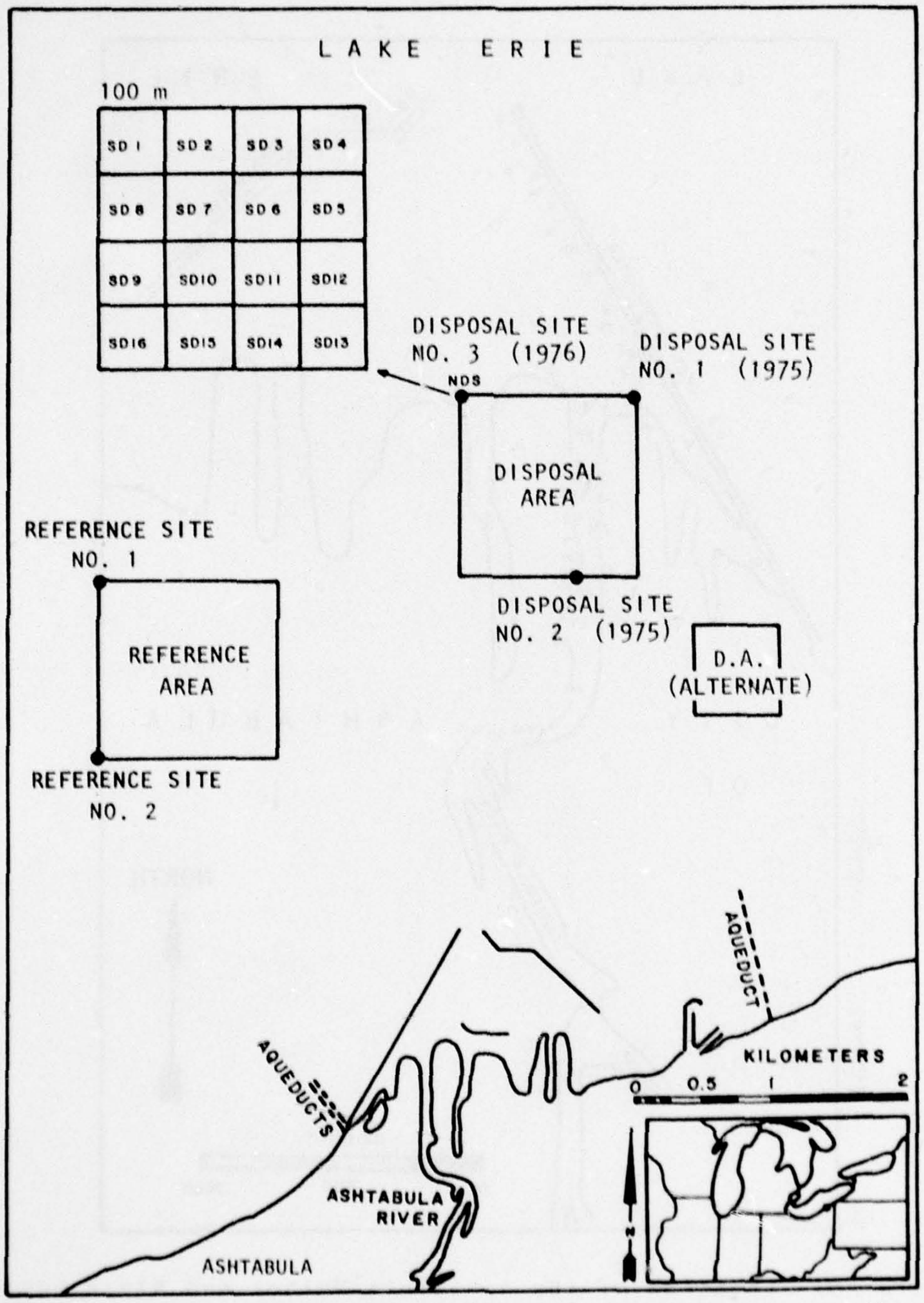

Figure A10. Description of quadrats for the northwest disposal site (NDS) investigated in 1976

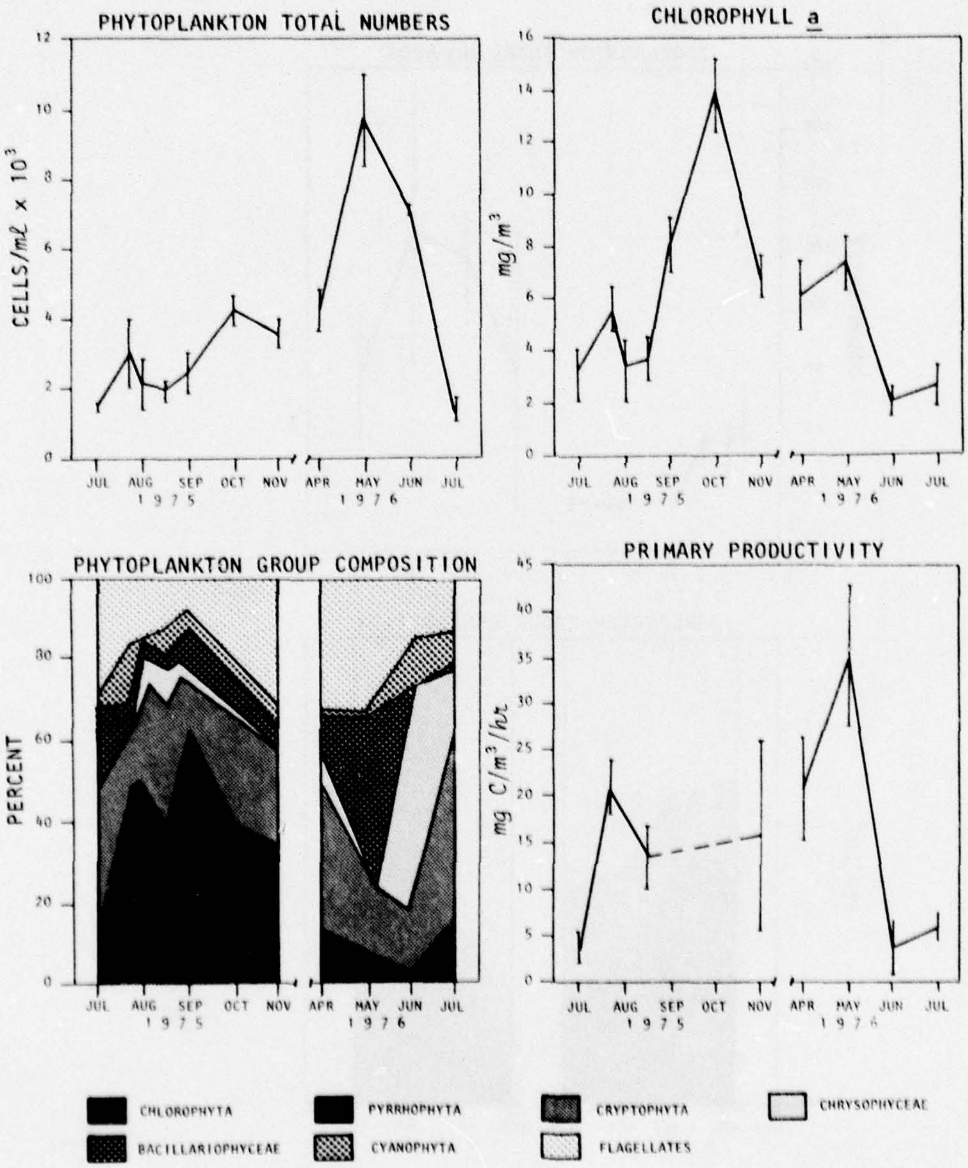

Figure A11. Mean temporal variation in surface phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity for reference sites PW1 and PW2, 30 July 1975 to 8 July 1976. Bars indicate 95 percent confidence intervals for means

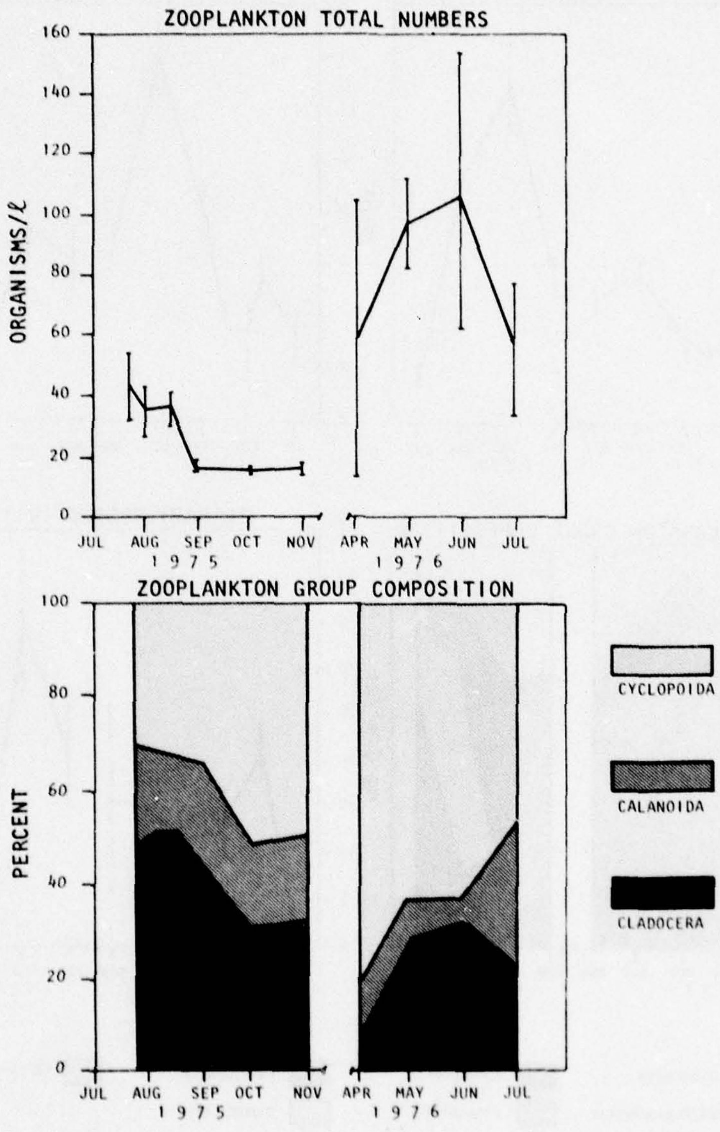

Figure A12. Mean temporal variation in zooplankton total number and group composition for reference sites PW1 and PW2, 30 July 1975 to 8 July 1976. Bars indicate 95 percent confidence intervals for means

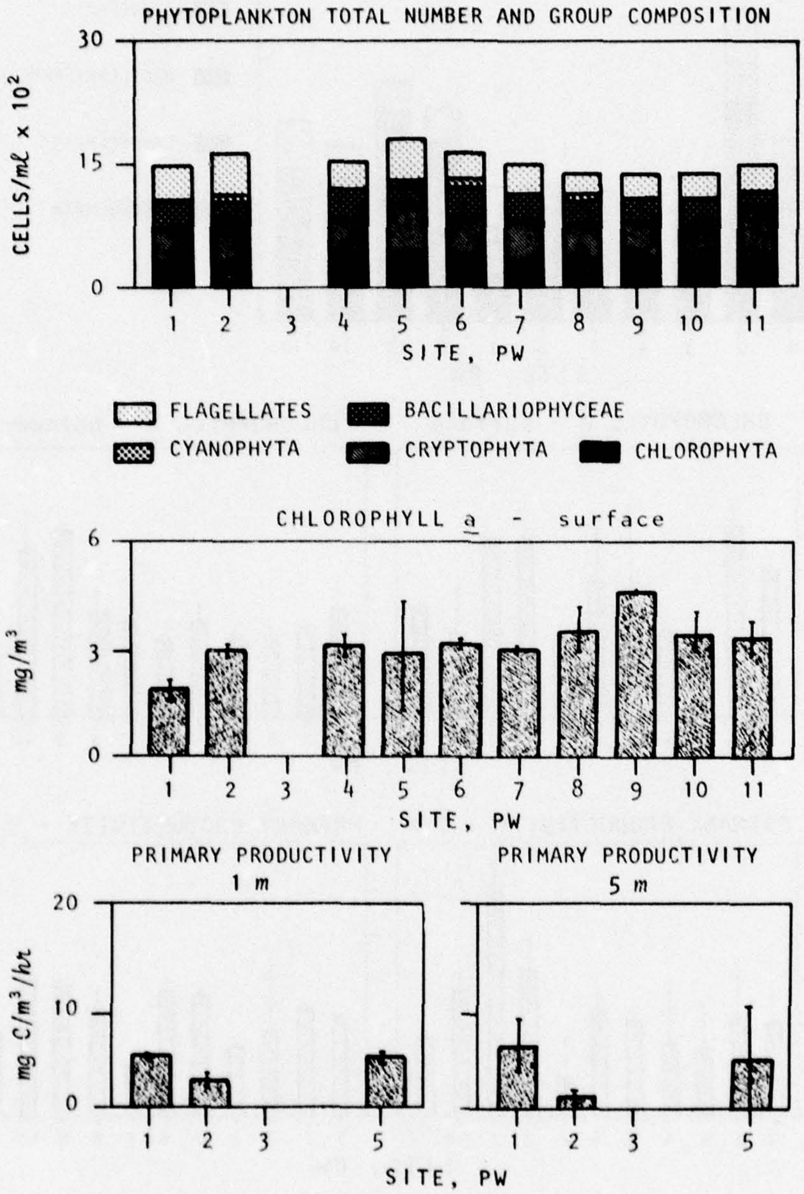

Figure A13. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between pelagic sampling sites PW1, PW2, and PW4-PW11 prior to disposal of dredged material, 9-11 July 1975

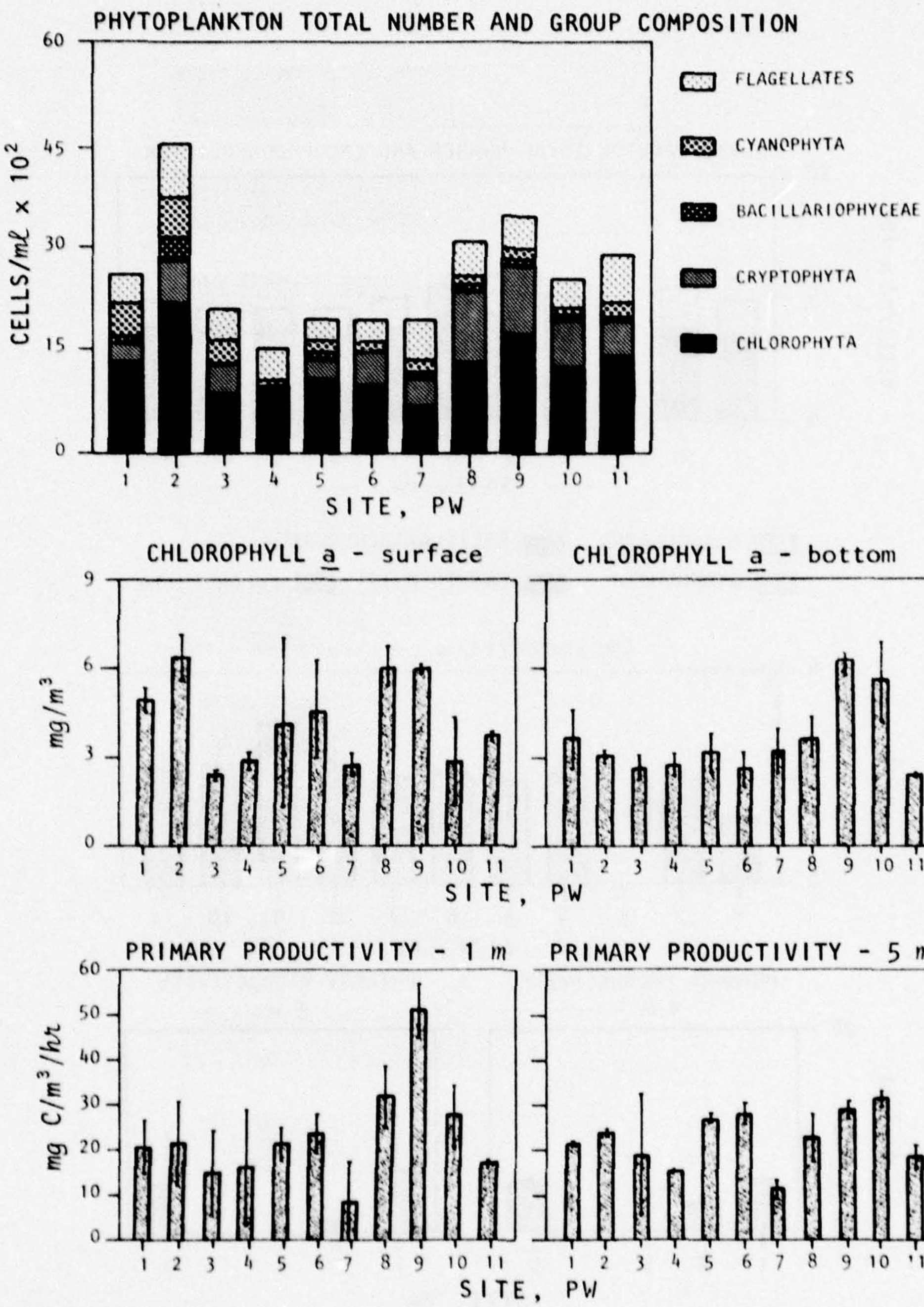

Figure A14. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between all pelagic sampling sites (PW1-PW11) prior to the disposal of dredged material, 30-31 July 1975

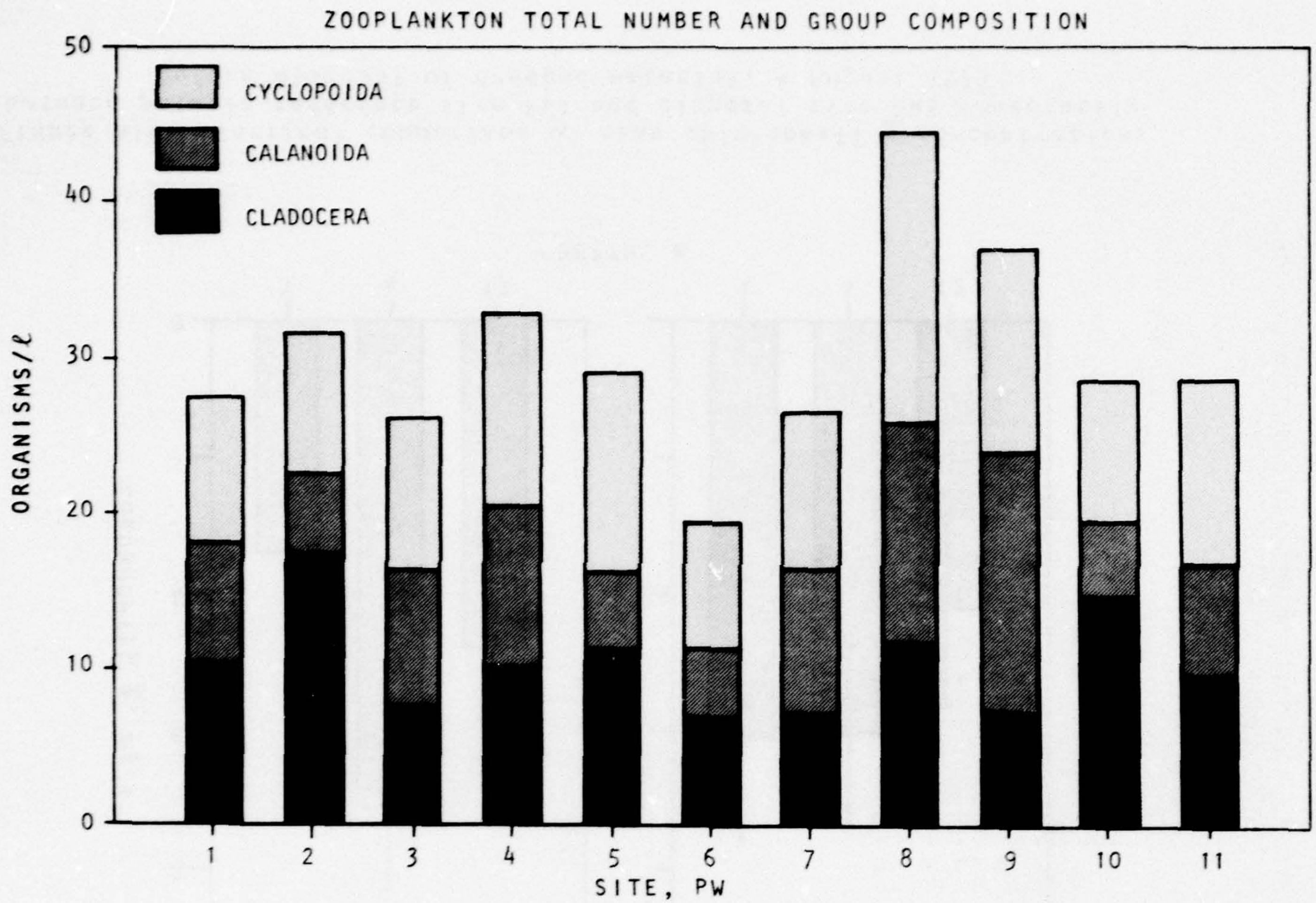

Figure A15. Variation in mean zooplankton total number and group composition between all pelagic sampling sites (PW1-PW11) prior to the disposal of dredged material, 30-31 July 1975

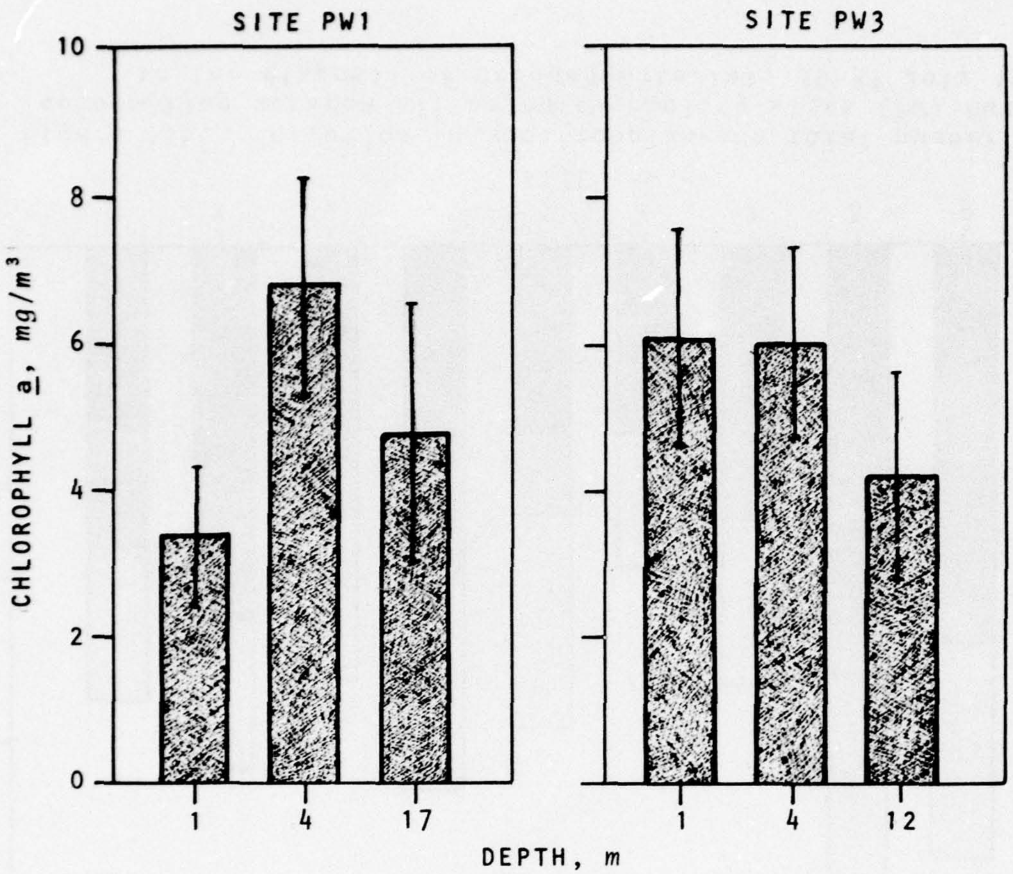

Figure A16. Vertical comparison of mean chlorophyll a concentrations between pelagic reference site PW1 and disposal site PW3 immediately before disposal of dredged material, 4 August 1975

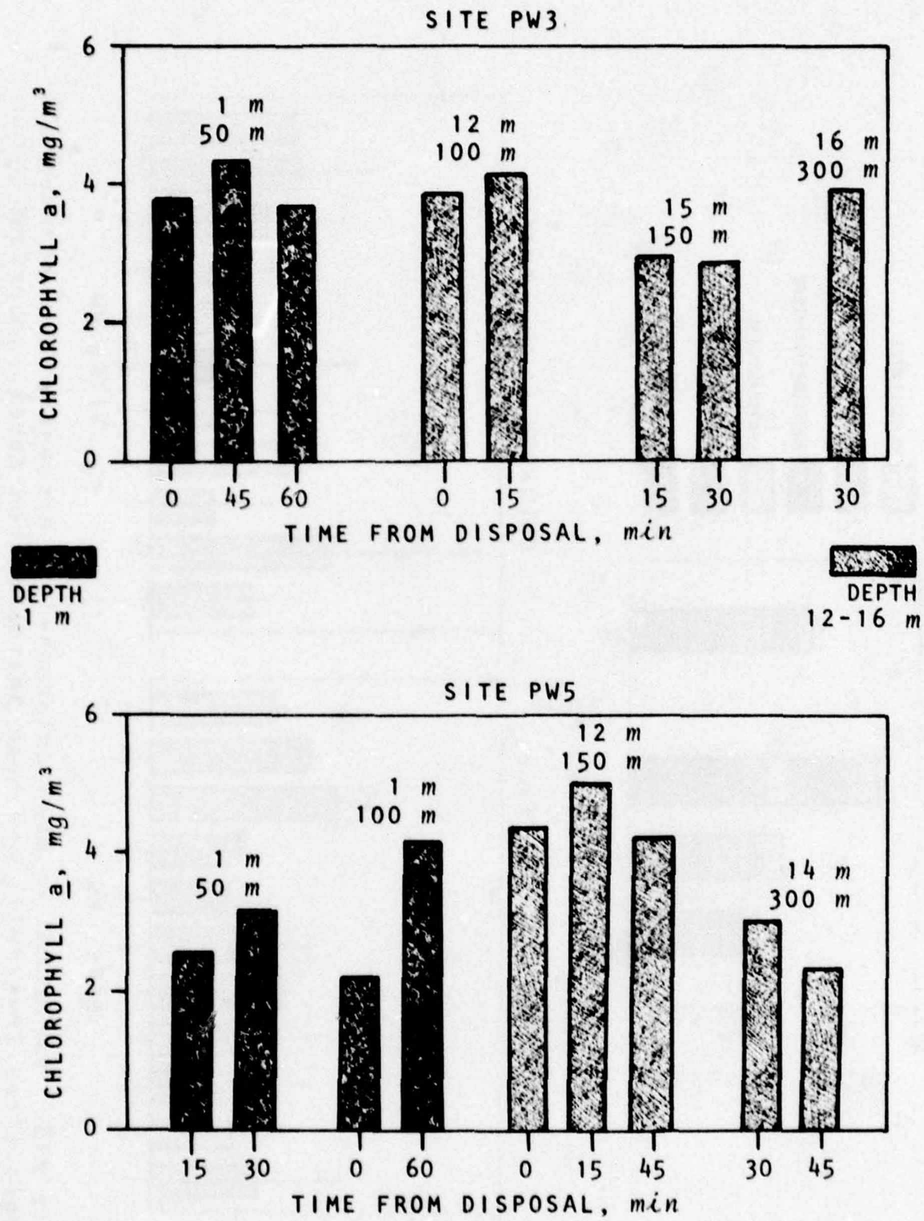

Figure A17. Temporal and vertical variation in chlorophyll a concentrations at specific distances away from disposal sites PW3 and PW5. (The first number indicates depth in meters and the second number indicates distance away from the disposal site in meters)

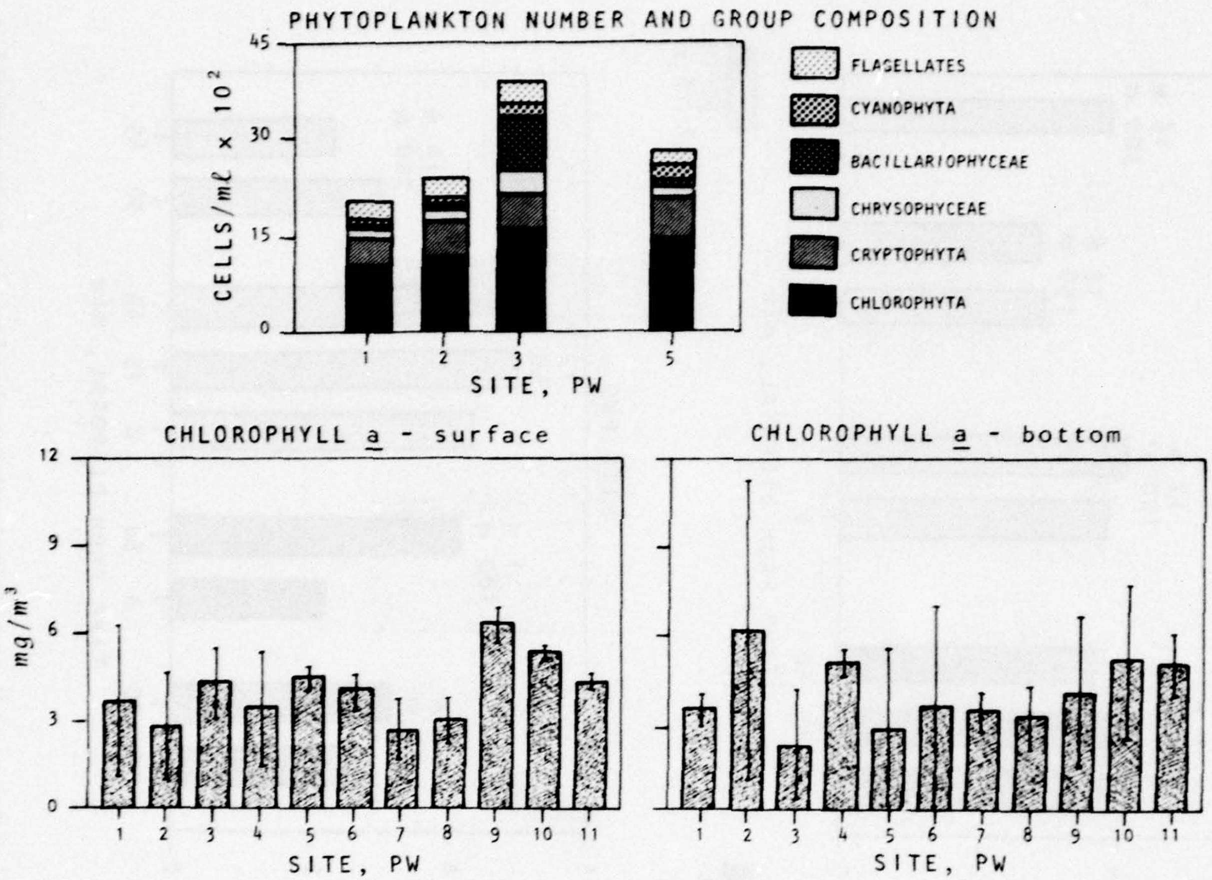

Figure A18. Variation in mean chlorophyll a concentrations between all pelagic sites (PW1-PW11) and mean phytoplankton total number and group composition between pelagic reference sites PW1 and PW2 and pelagic disposal sites PW3 and PW5 immediately after the disposal of dredged material, 14 August 1975

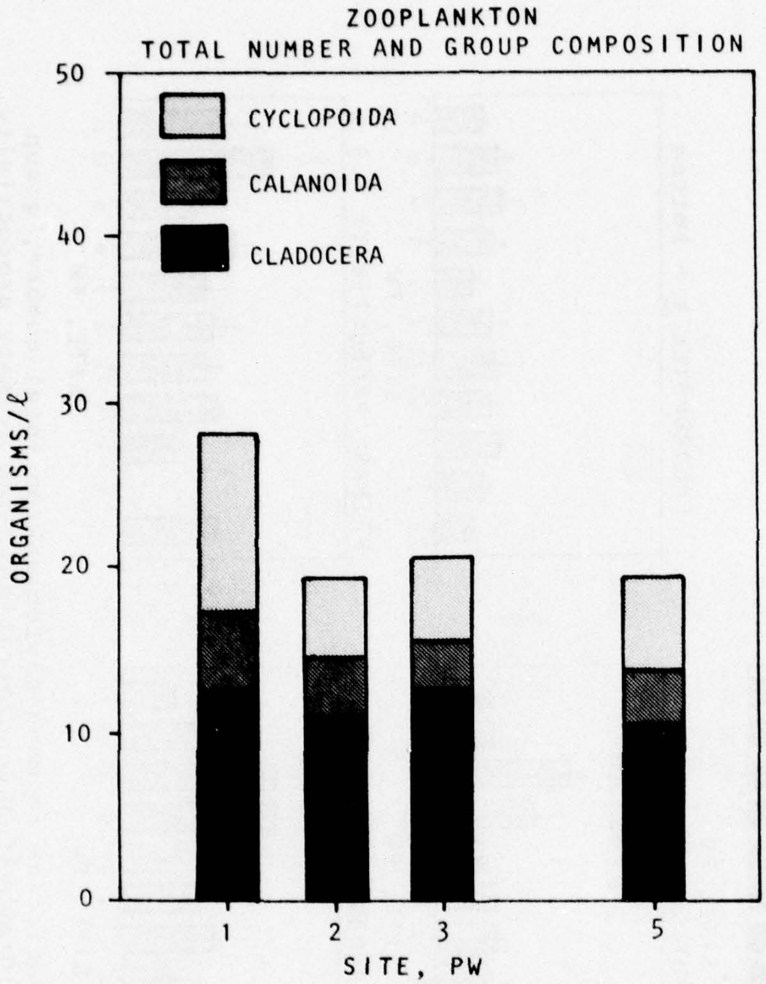

Figure A19. Variation in mean zooplankton total number and group composition between pelagic reference sites PW1 and PW2 and pelagic disposal sites PW3 and PW5 immediately after the disposal of dredged material, 14 August 1975

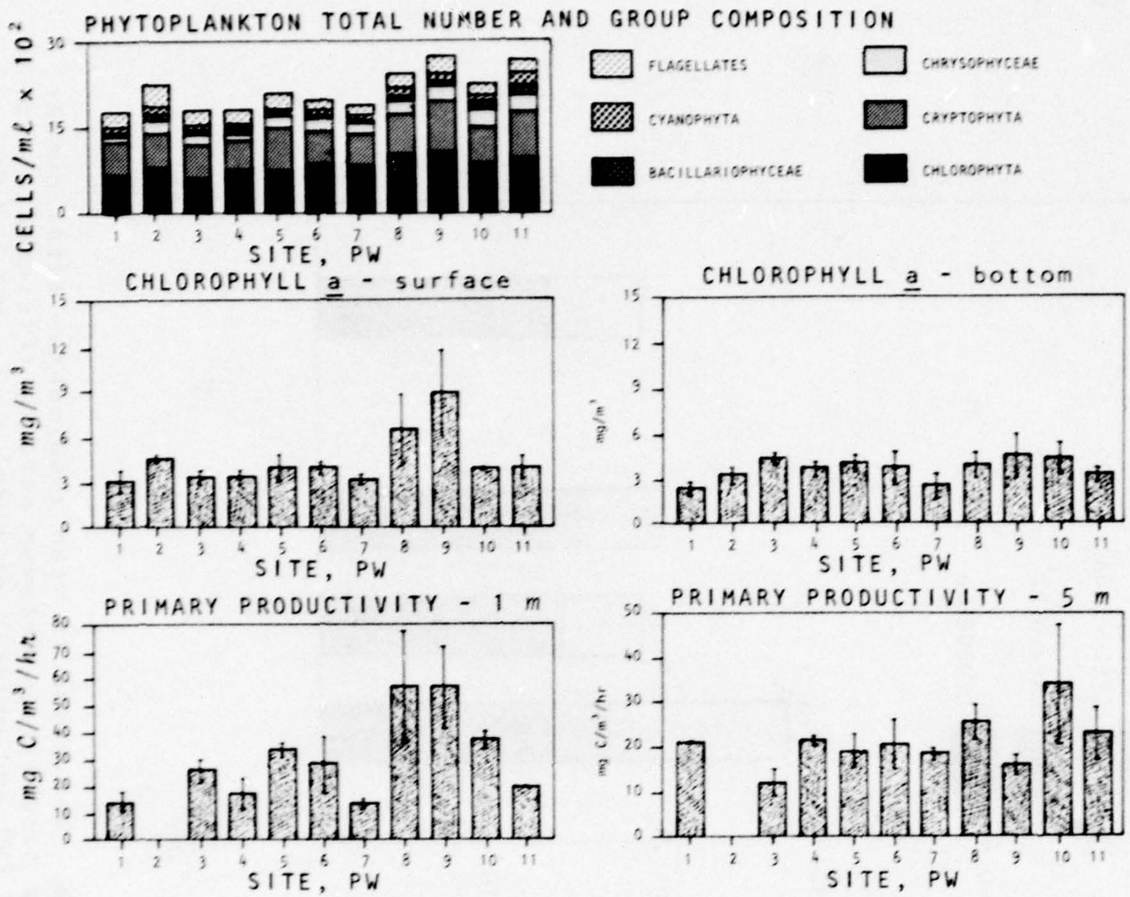

Figure A20. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between all pelagic sampling sites (PW1-PW11) 5 days after the disposal of dredged material, 19-20 August 1975. (Station PW2 was not sampled for primary productivity estimates)

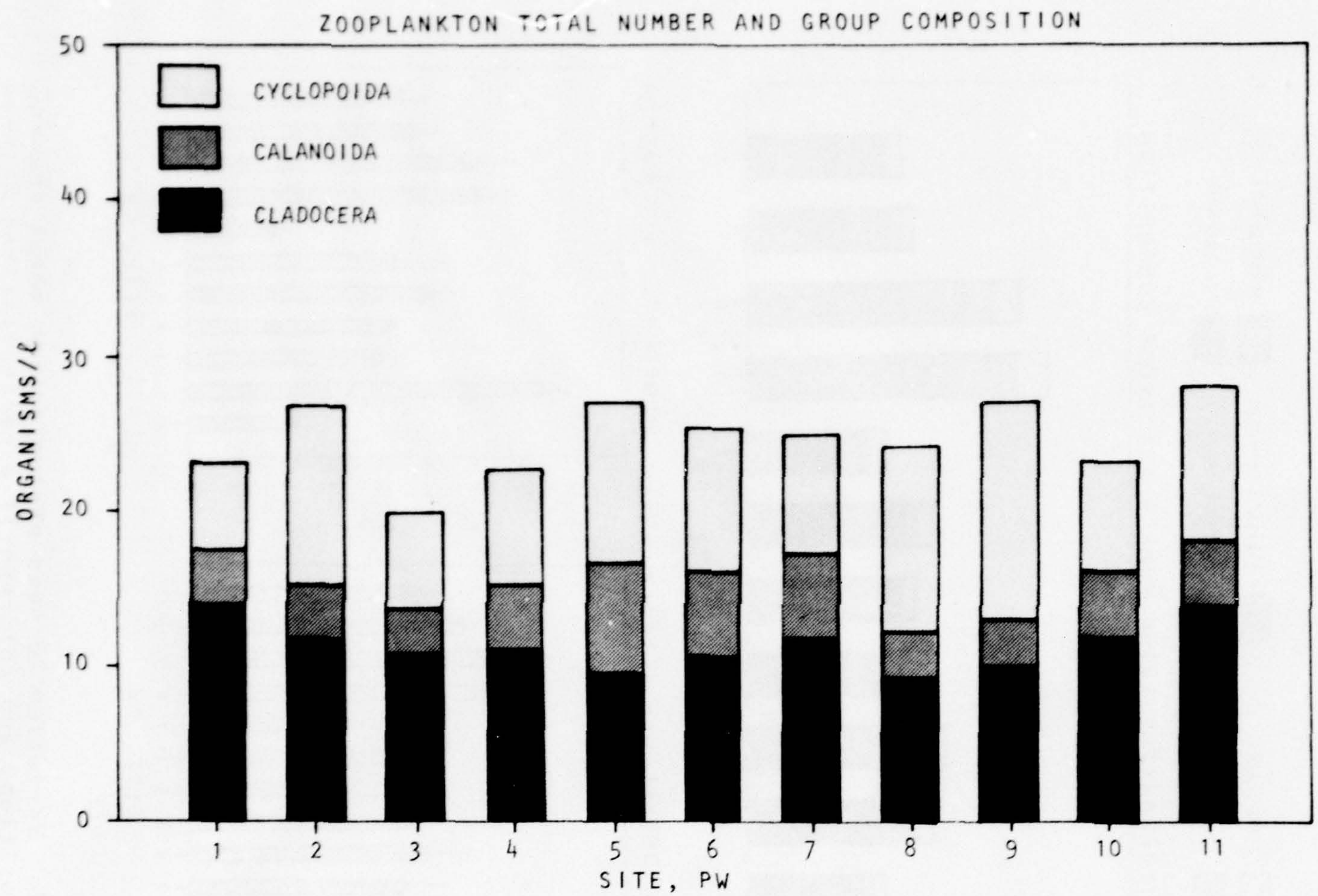

Figure A21. Variation in mean zooplankton total number and group composition between all pelagic sampling sites (PW1-PW11) 5 days after the disposal of dredged material, 19-20 August 1975

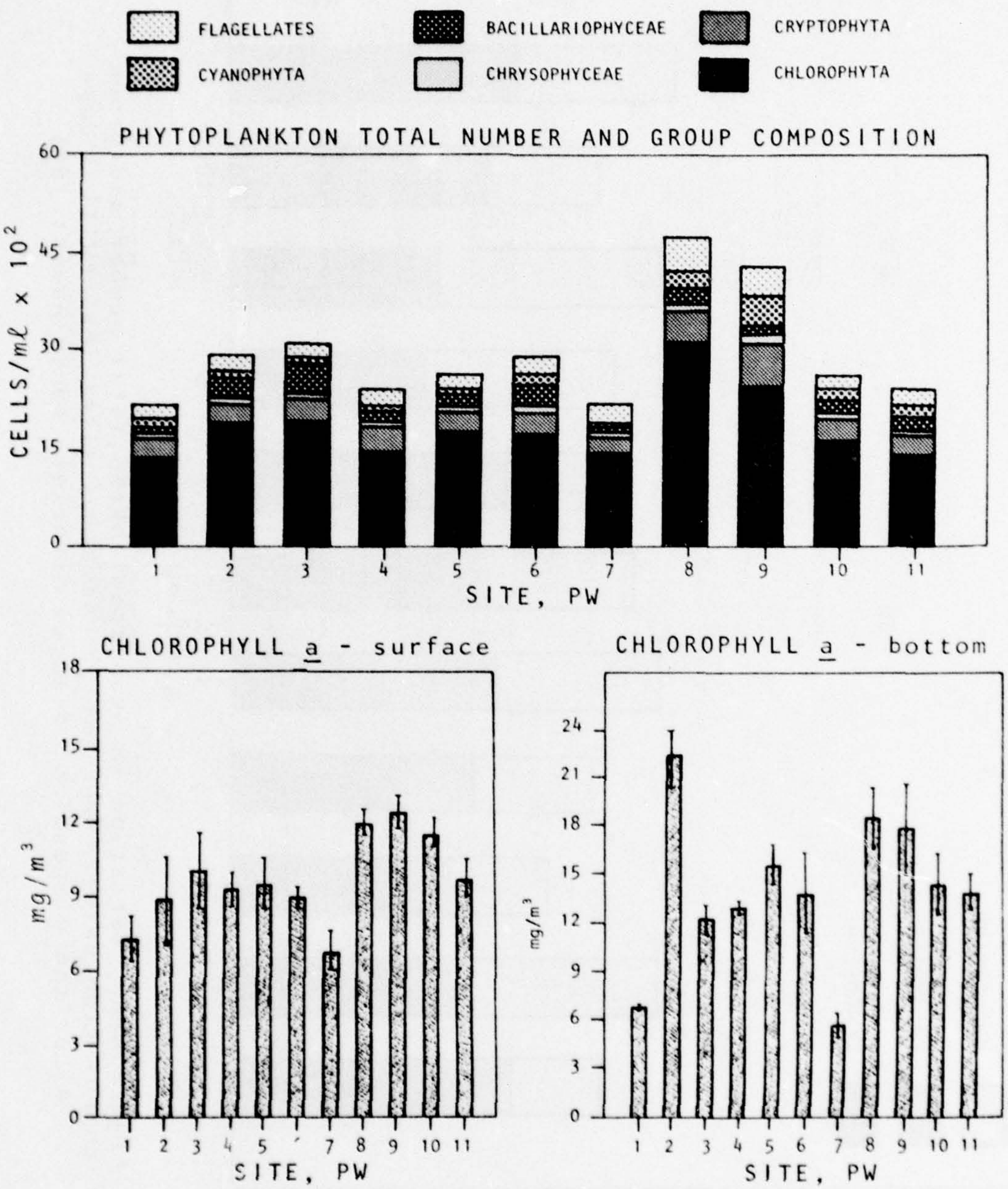

Figure A22. Variation in mean phytoplankton total number, group composition, and chlorophyll a concentrations between all pelagic sampling sites (PW1-PW11) 30 days after the disposal of dredged material, 14 September 1975

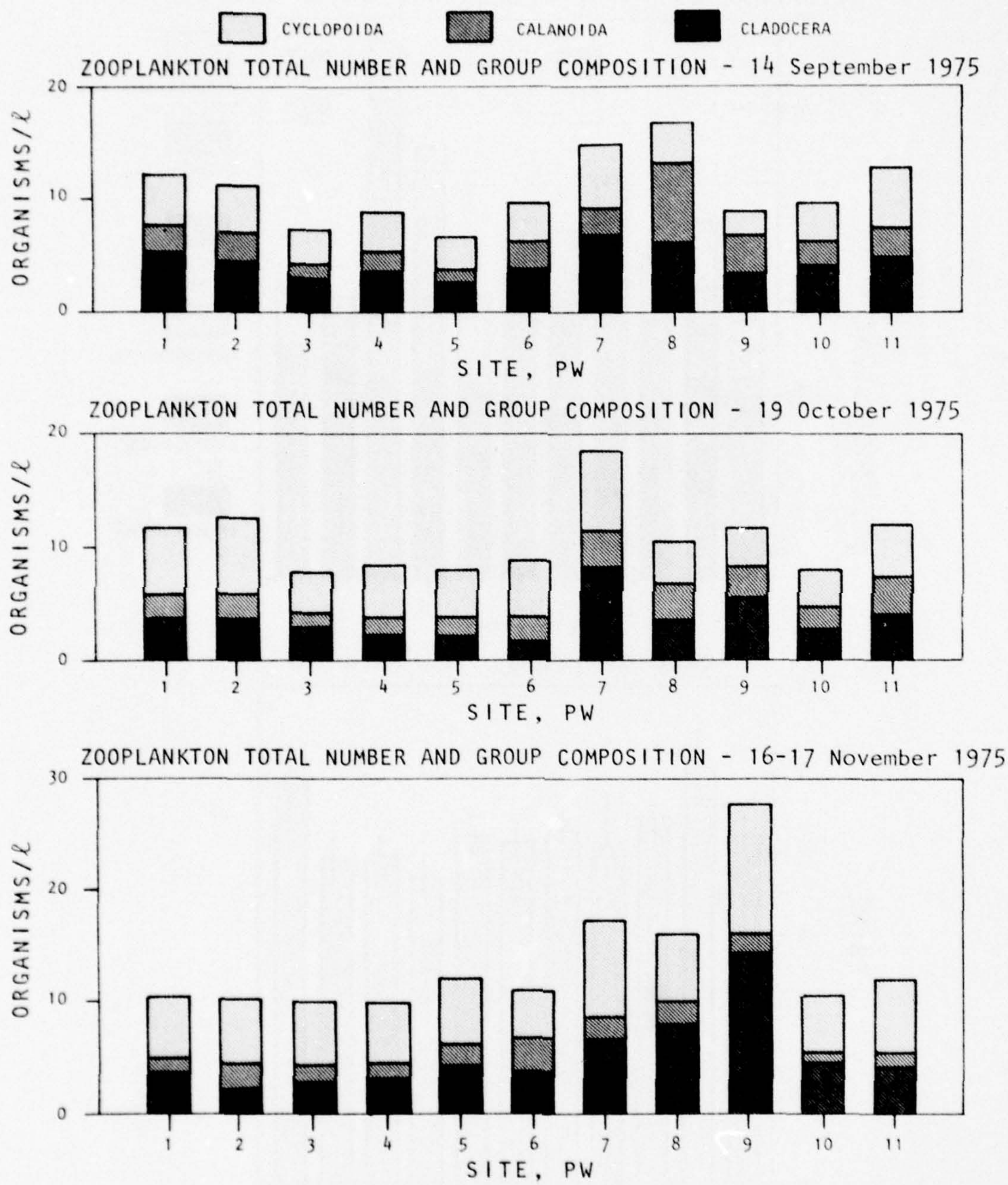

Figure A23. Variation in mean zooplankton total number and group composition between all pelagic sampling sites (PW1-PW11) 30 days (14 September), 60 days (19 October), and 90 days (16-17 November) after the disposal of dredged material (1975)

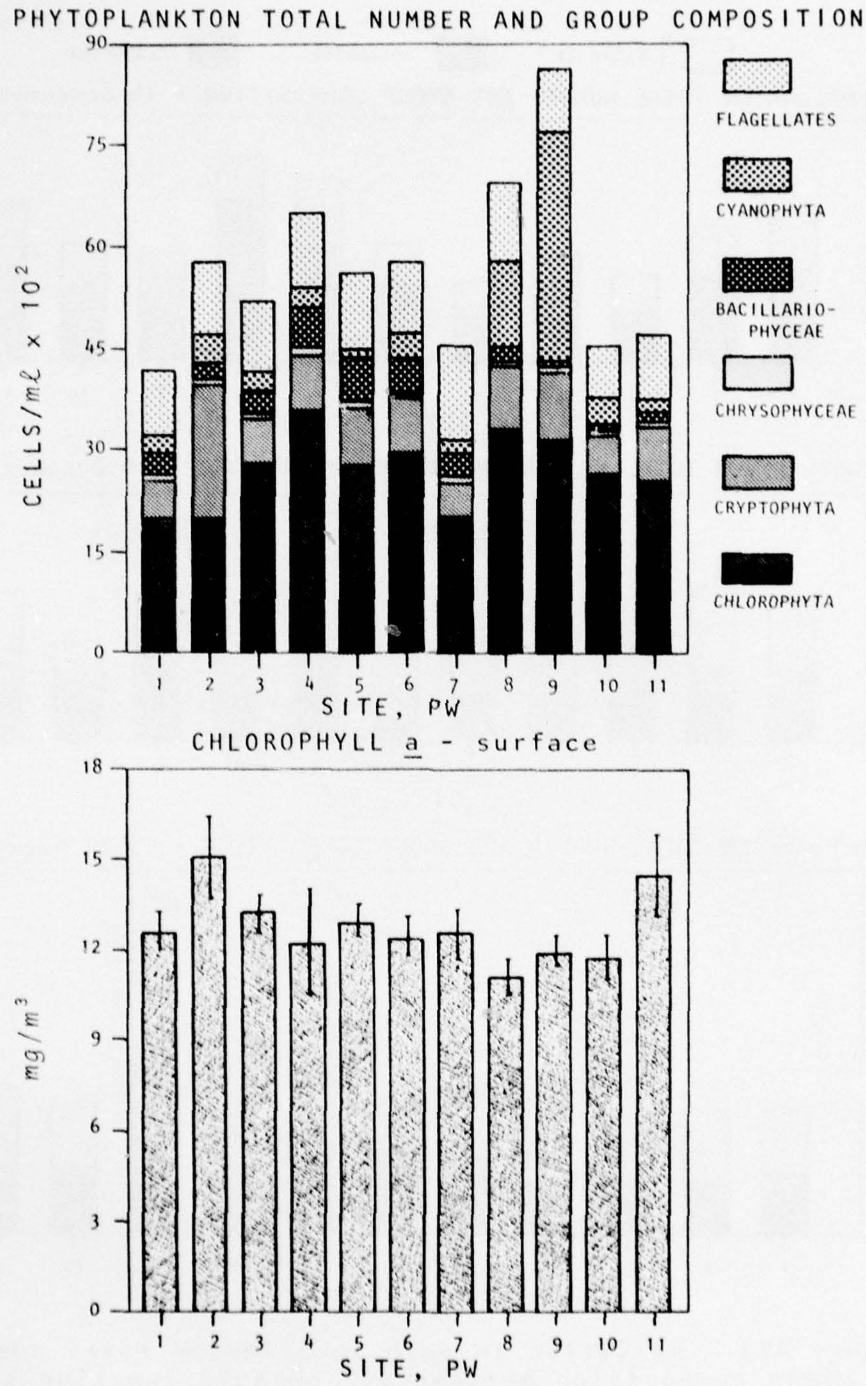

Figure A24. Variation in mean phytoplankton total number, group composition, and chlorophyll a concentrations between all pelagic sampling sites (PW1-PW11) 60 days after the disposal of dredged material, 19 October 1975

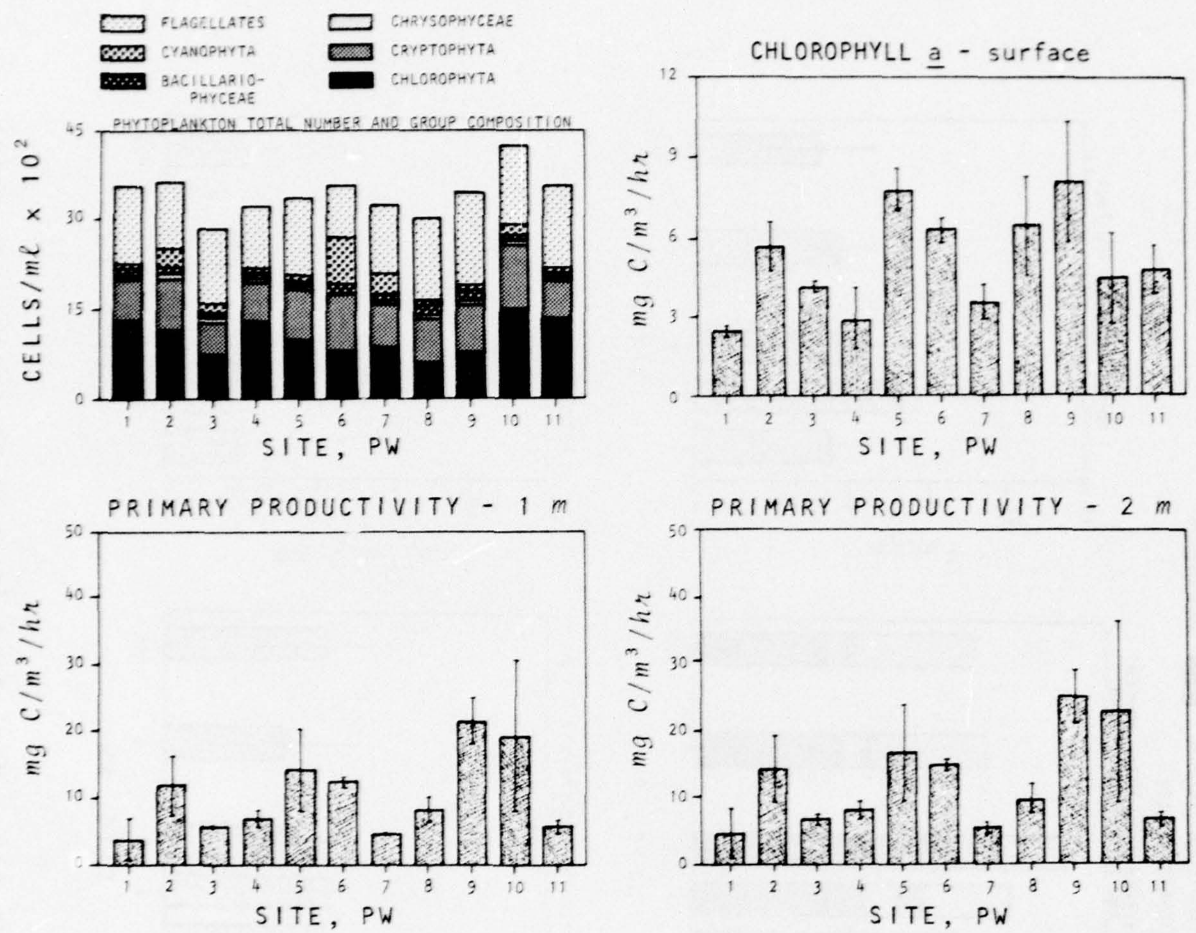

Figure A25. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between all pelagic sampling sites (PW1-PW11) 90 days after the disposal of dredged material, 16-17 November 1975

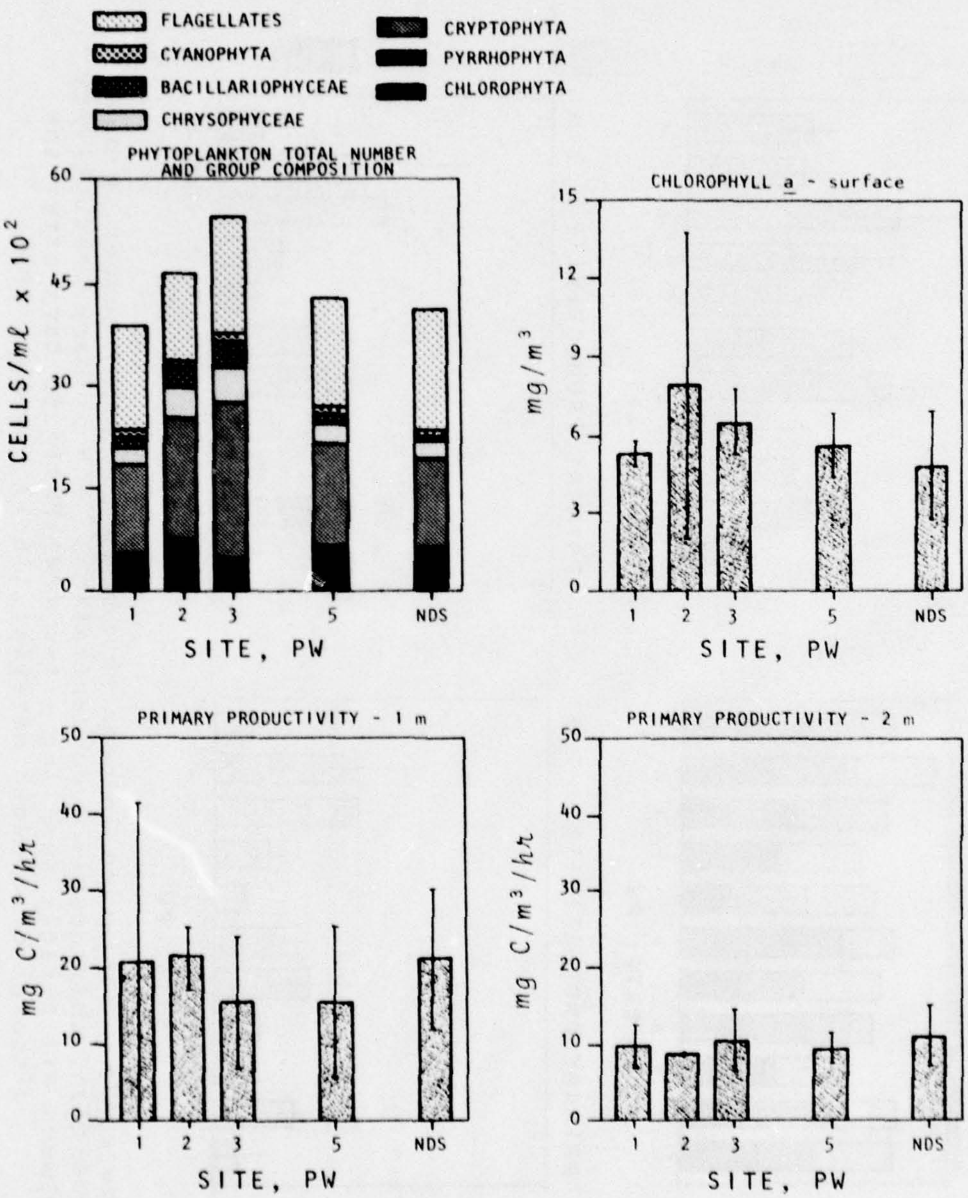

Figure A26. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between pelagic reference sites PW1 and PW2, pelagic disposal sites for 1975 PW3 and PW5, and the northwest disposal site, 21 April 1976

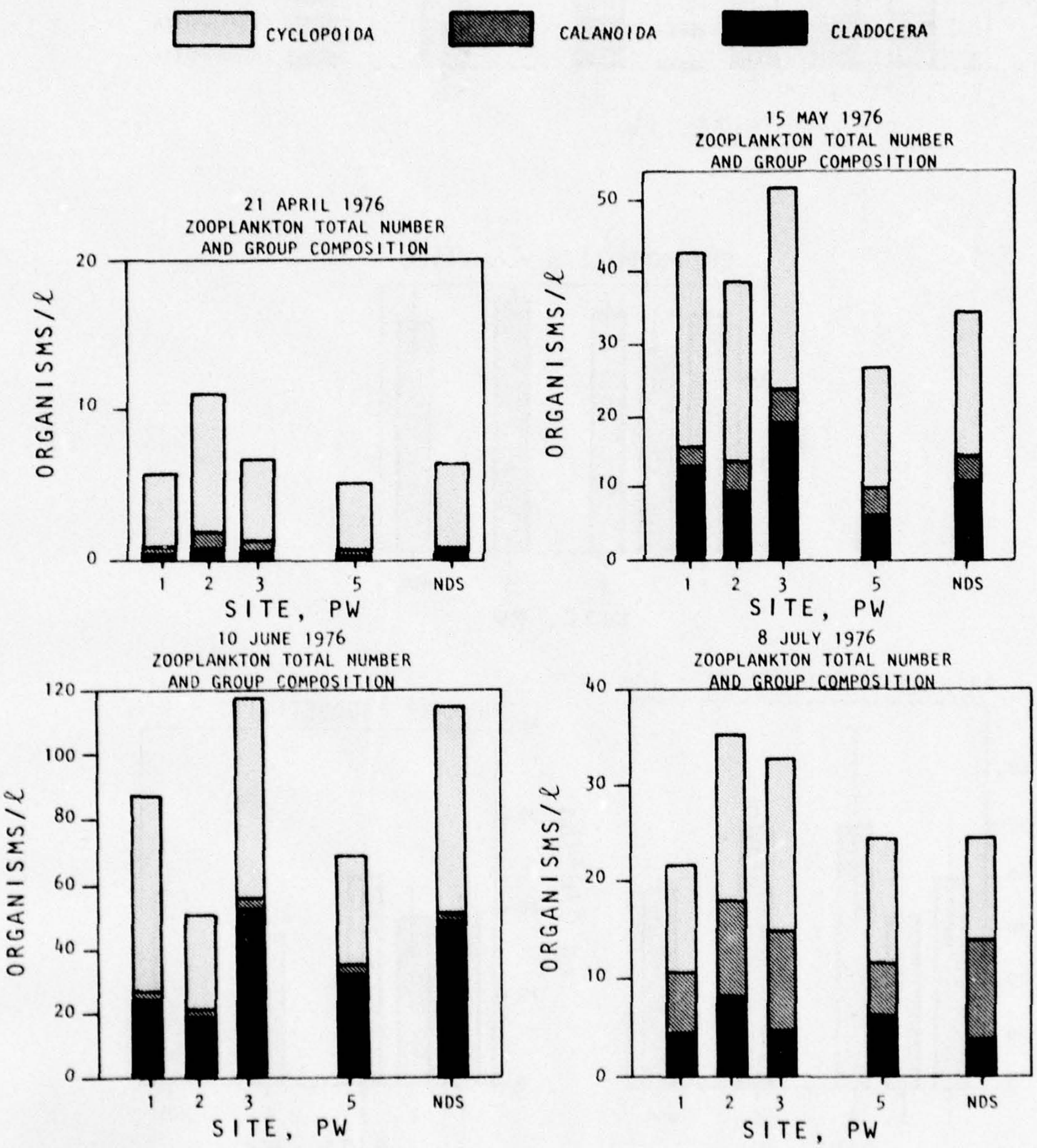

Figure A27. Variation in mean zooplankton total number and group composition between pelagic reference sites PW1 and PW2, pelagic disposal sites for 1975 PW3 and PW5, and the northwest disposal site for the sampling period 21 April, 15 May, 10 June, and 8 July 1976

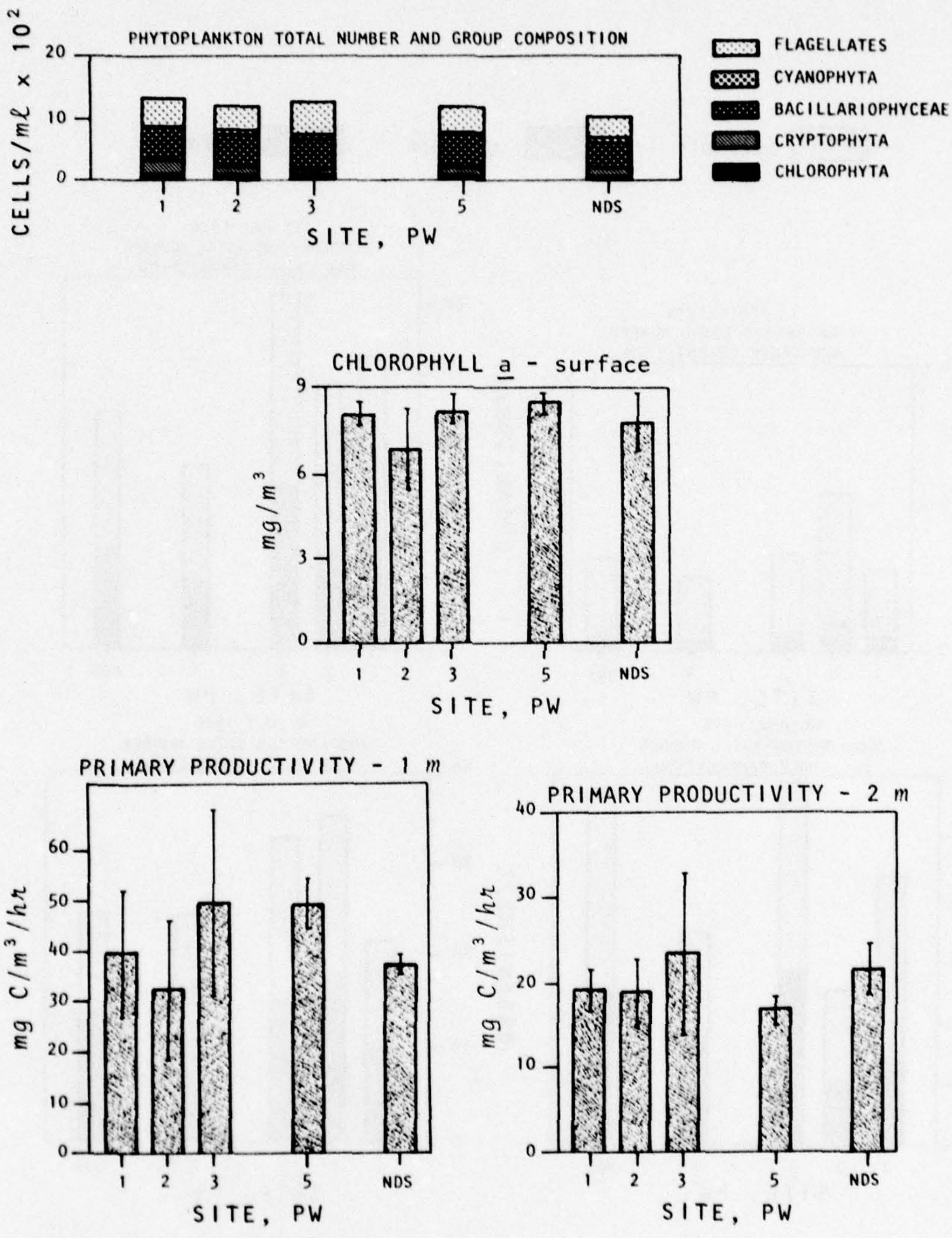

Figure A28. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between pelagic reference sites PW1 and PW2, pelagic disposal sites for 1975 PW3 and PW5, and the northwest disposal site for 1976 (NDS) prior to the disposal of dredged material, 15-16 May 1976

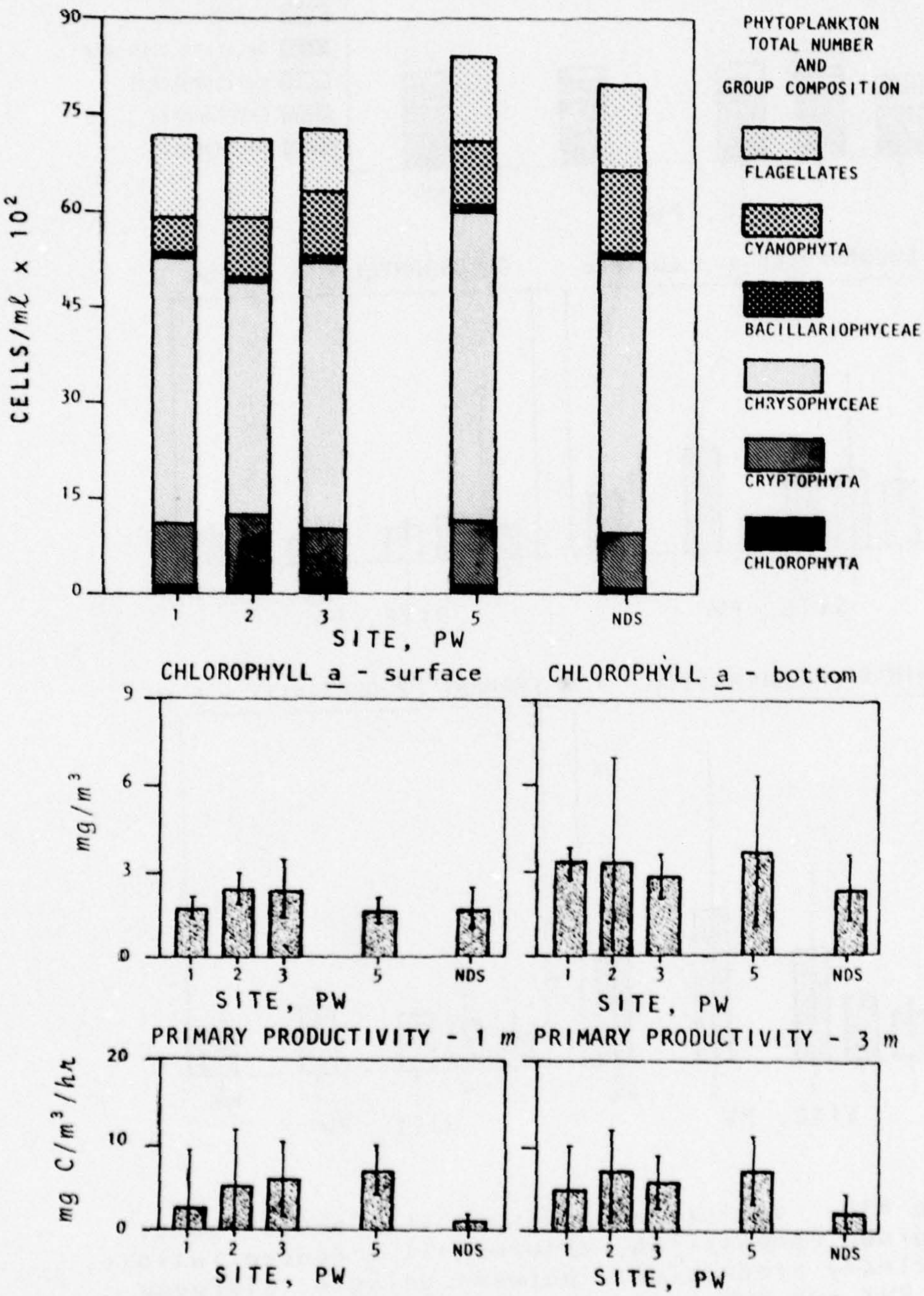

Figure A29. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between pelagic reference sites PW1 and PW2, pelagic disposal sites for 1975 PW3 and PW5, and the northwest disposal site for 1976 (NDS) 5 days after the disposal of dredged material, 10-11 June 1976

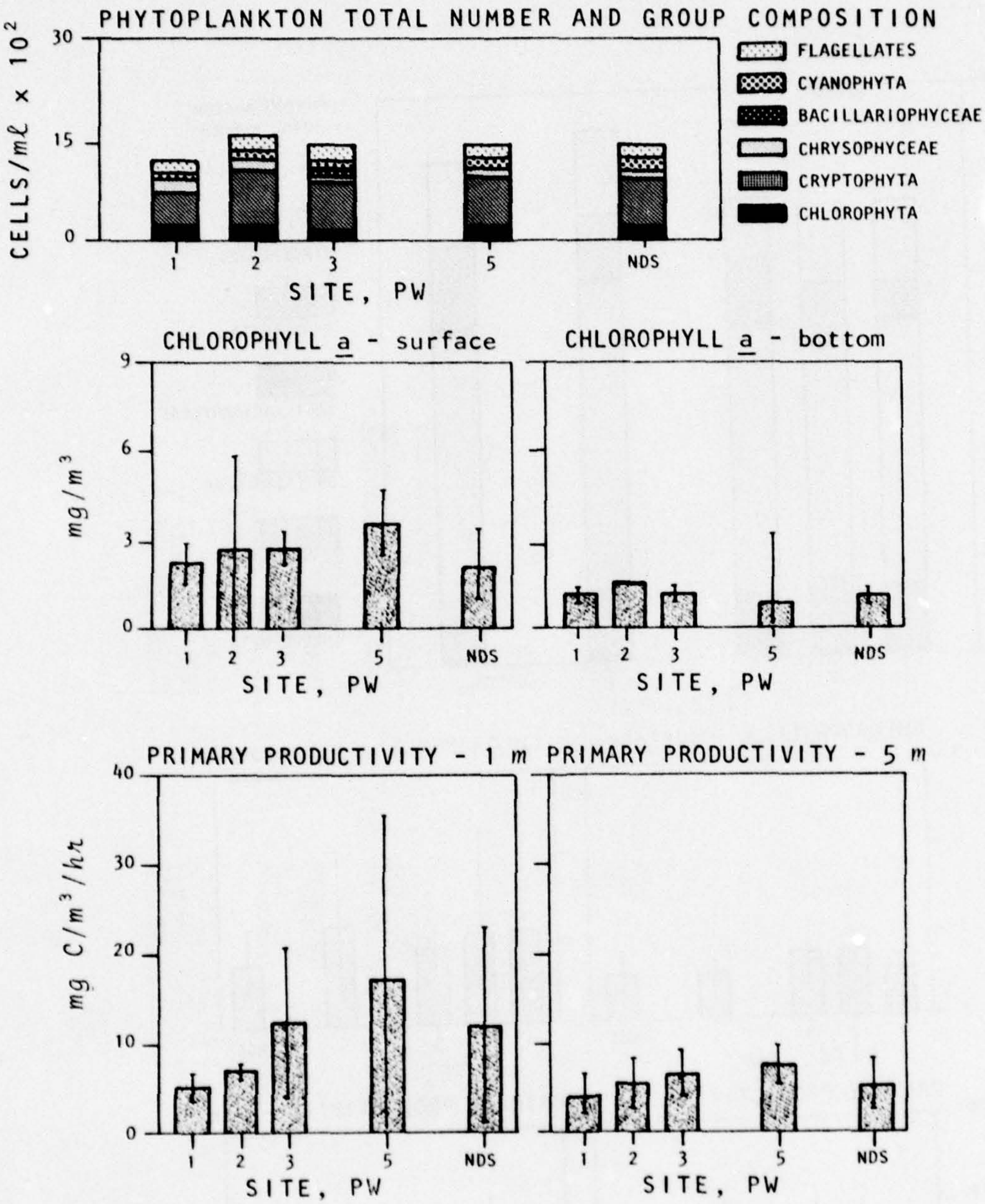

Figure A30. Variation in mean phytoplankton total number, group composition, chlorophyll a concentrations, and primary productivity between pelagic reference sites PW1 and PW2, pelagic disposal sites for 1975 PW3 and PW5, and the northwest disposal site for 1976 (NDS) 30 days after the disposal of dredged material, 7-8 July 1976

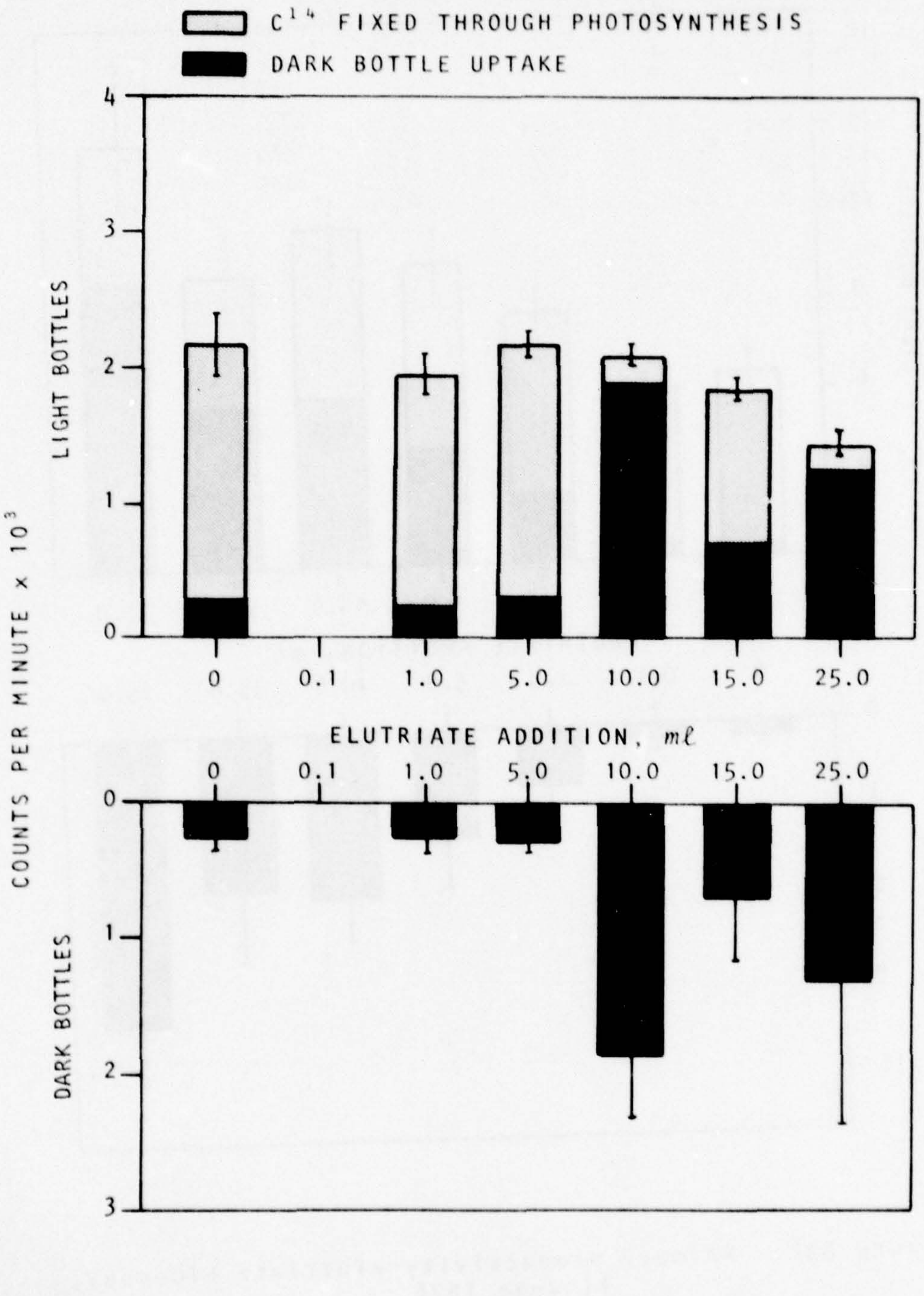

Figure A31. Primary productivity-elutriate bioassay, 15 May 1976

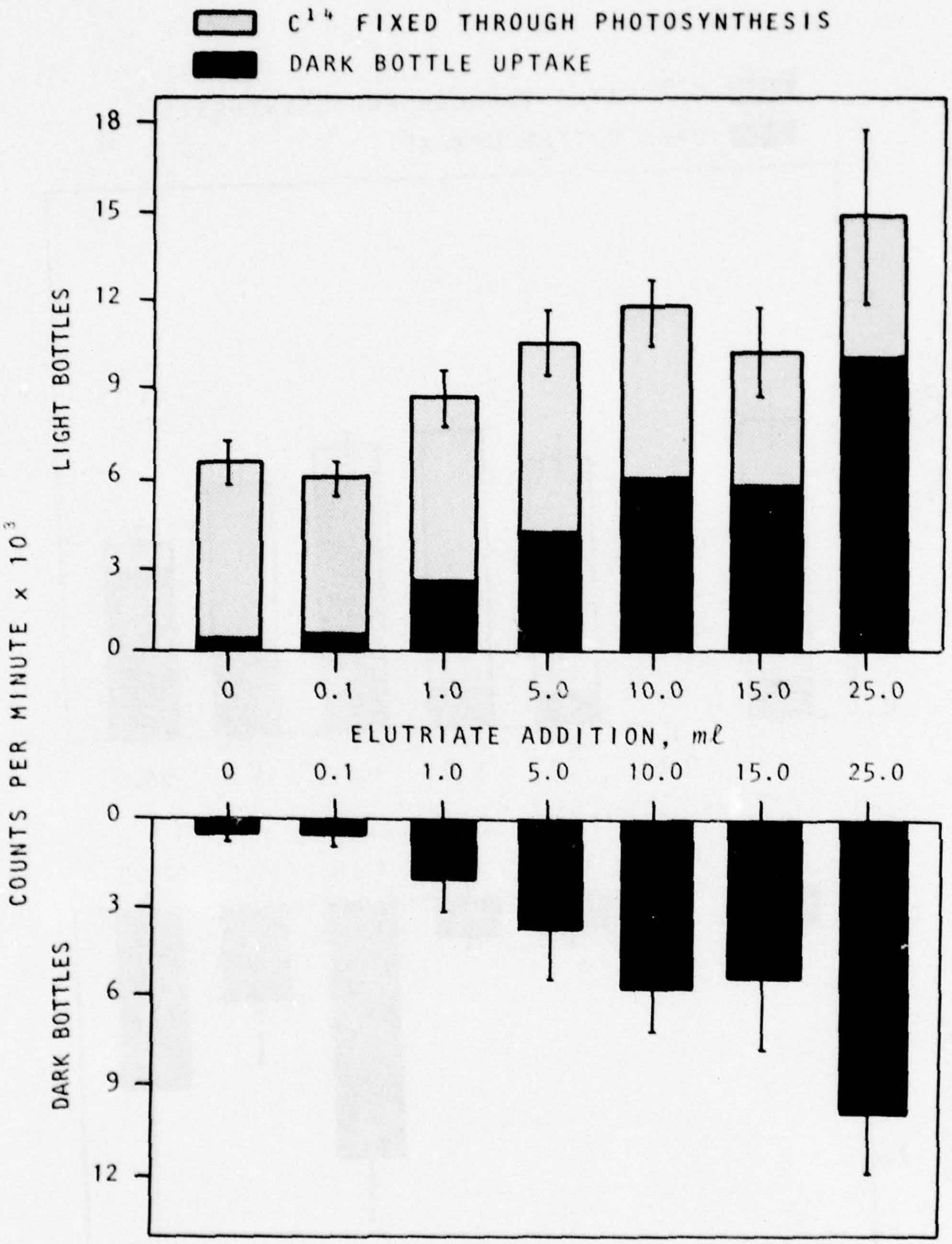

Figure A32. Primary productivity-elutriate bioassay, 11 June 1976

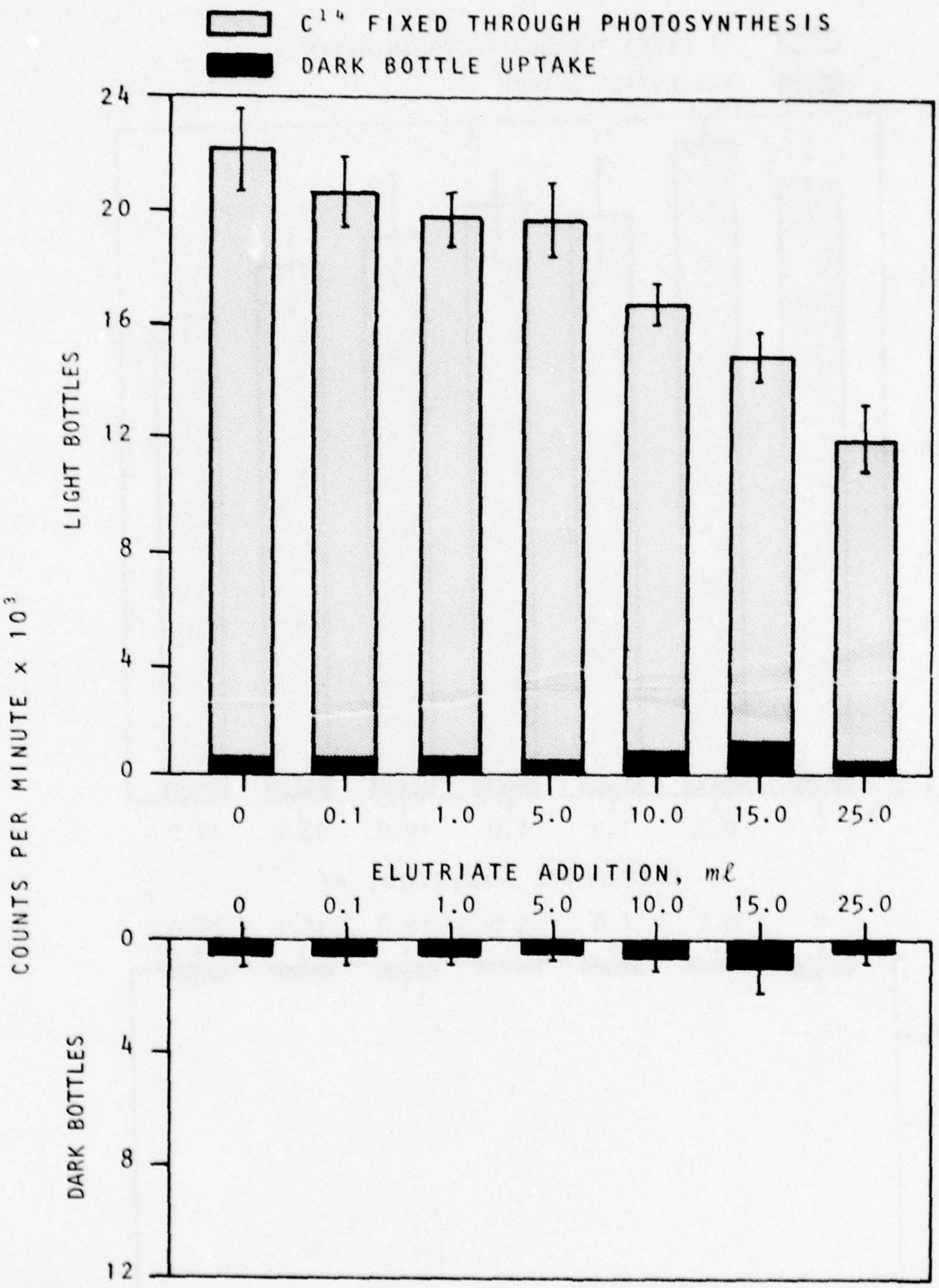

Figure A33. Primary productivity-elutriate bioassay, 27 July 1976

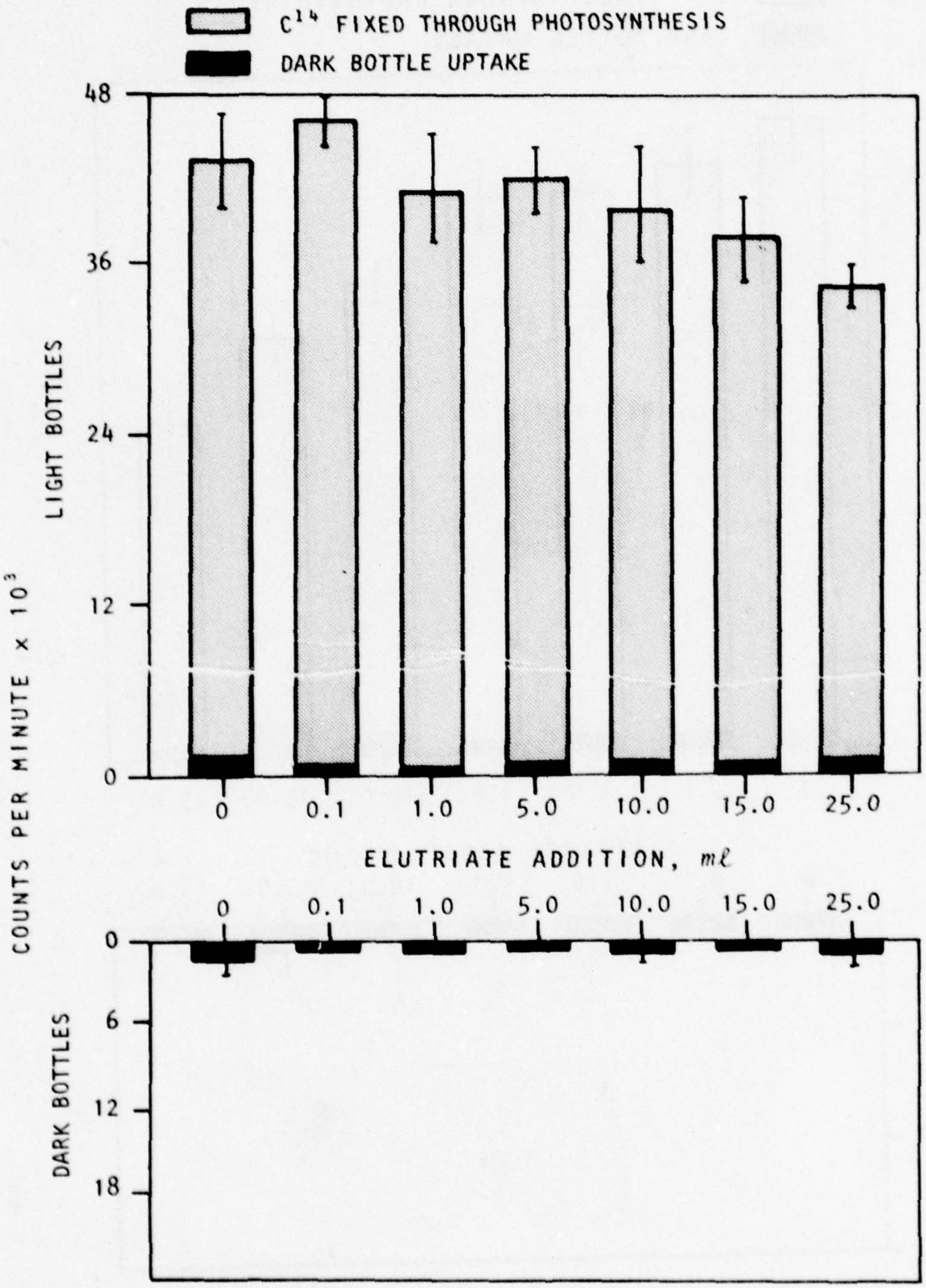

Figure A34. Primary productivity-elutriate bioassay, 14 September 1976

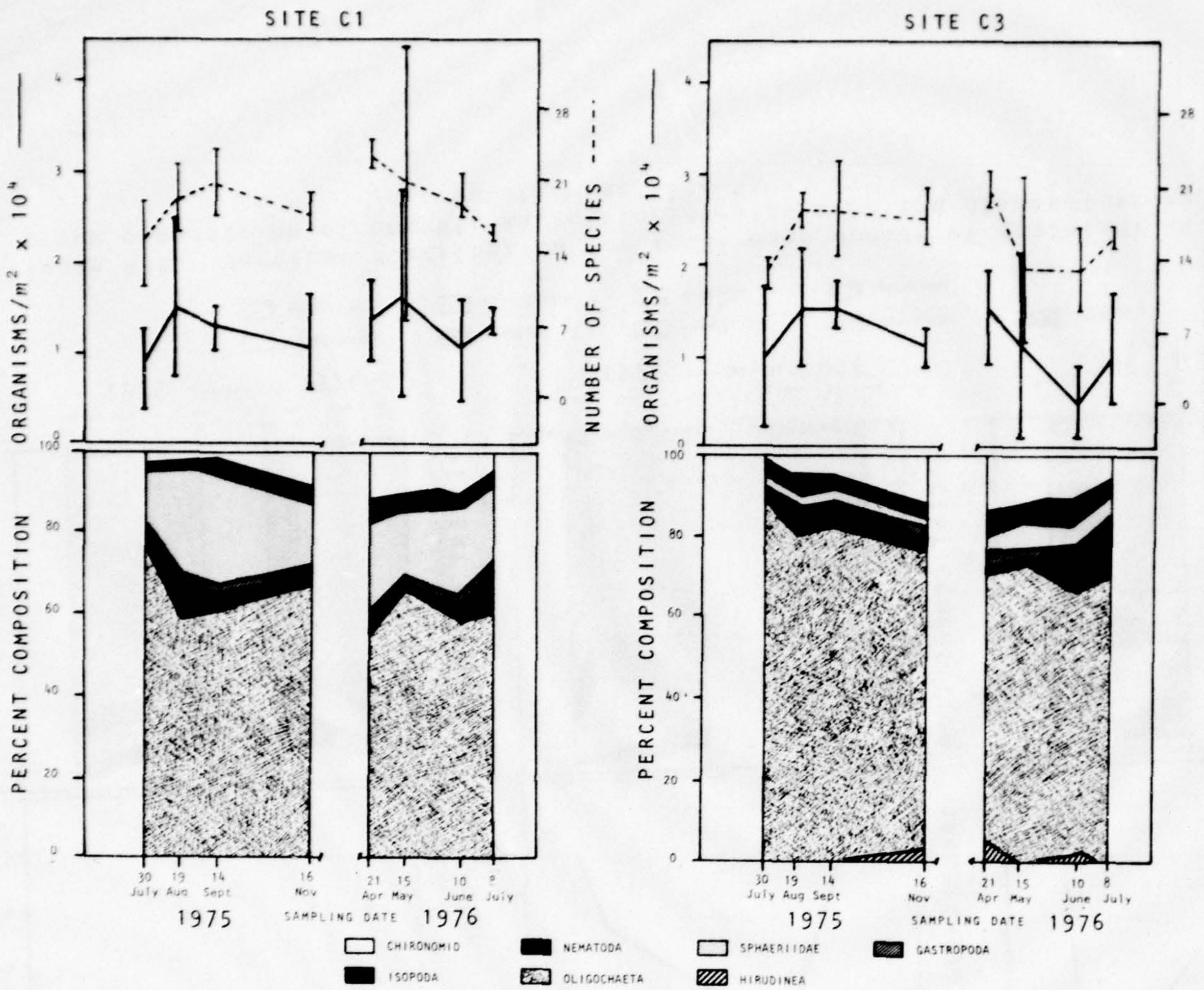

Figure A35. Total mean number of organisms, species number, and group composition of benthic macroinvertebrates at reference sites C1 and C3 over the duration of the disposal study. Bars represent 95 percent confidence intervals

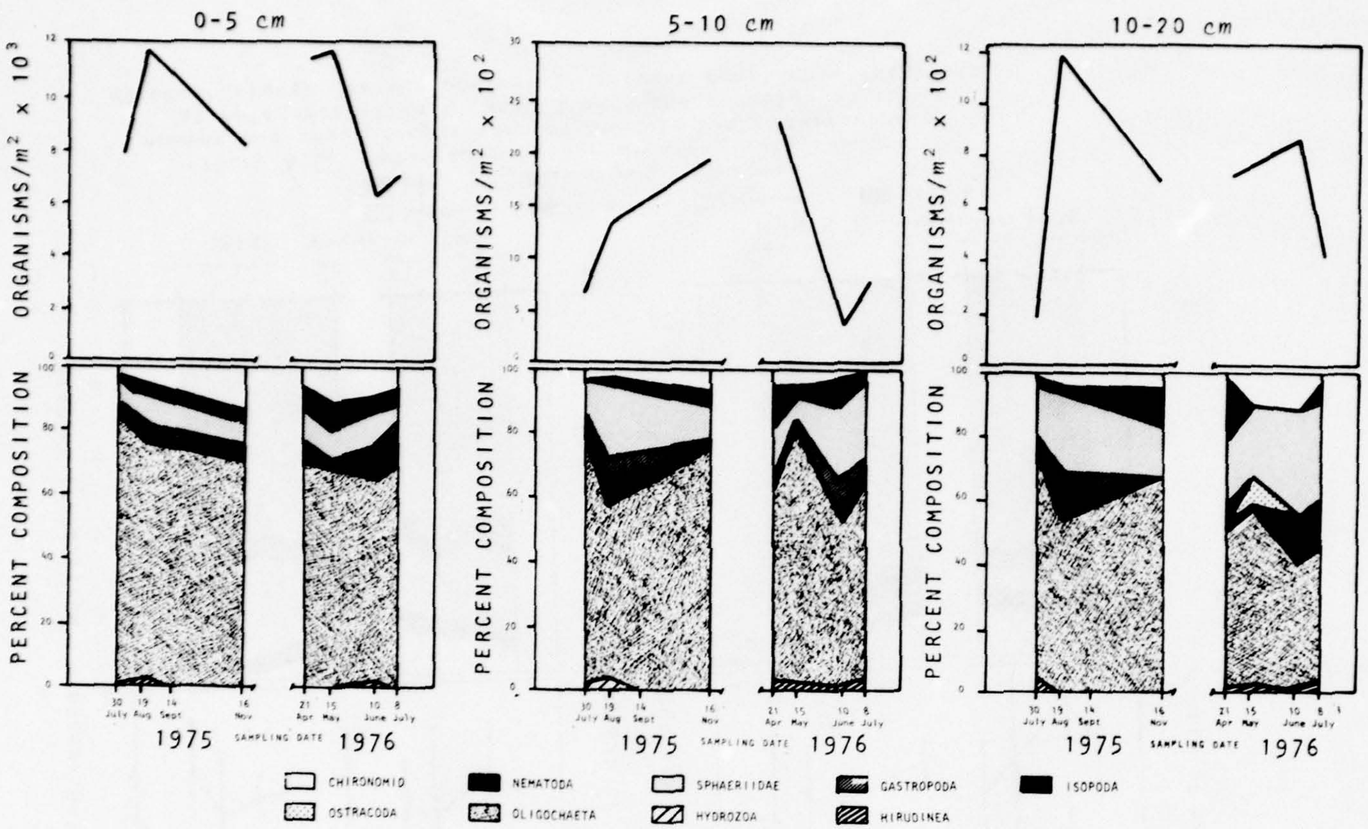

Figure A36. Vertical distribution for total mean number of organisms and group composition of benthic macroinvertebrates over the disposal study duration at site C3

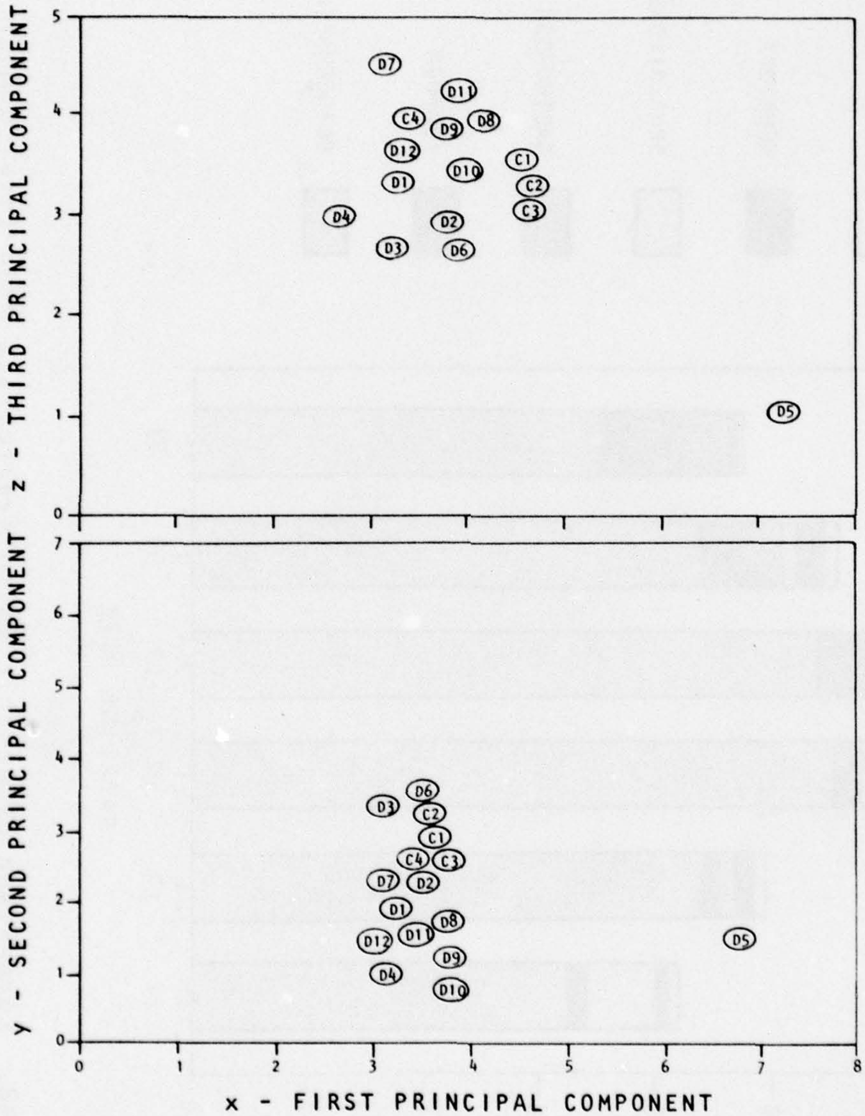

Figure A37. Community ordination (three principal components) of benthic macroinvertebrate logarithmic data for all sites sampled on 31 July 1975. Axis values are in ordination units while distance between sites reflects community similarity. Alphanumeric symbols are site labels as in the text

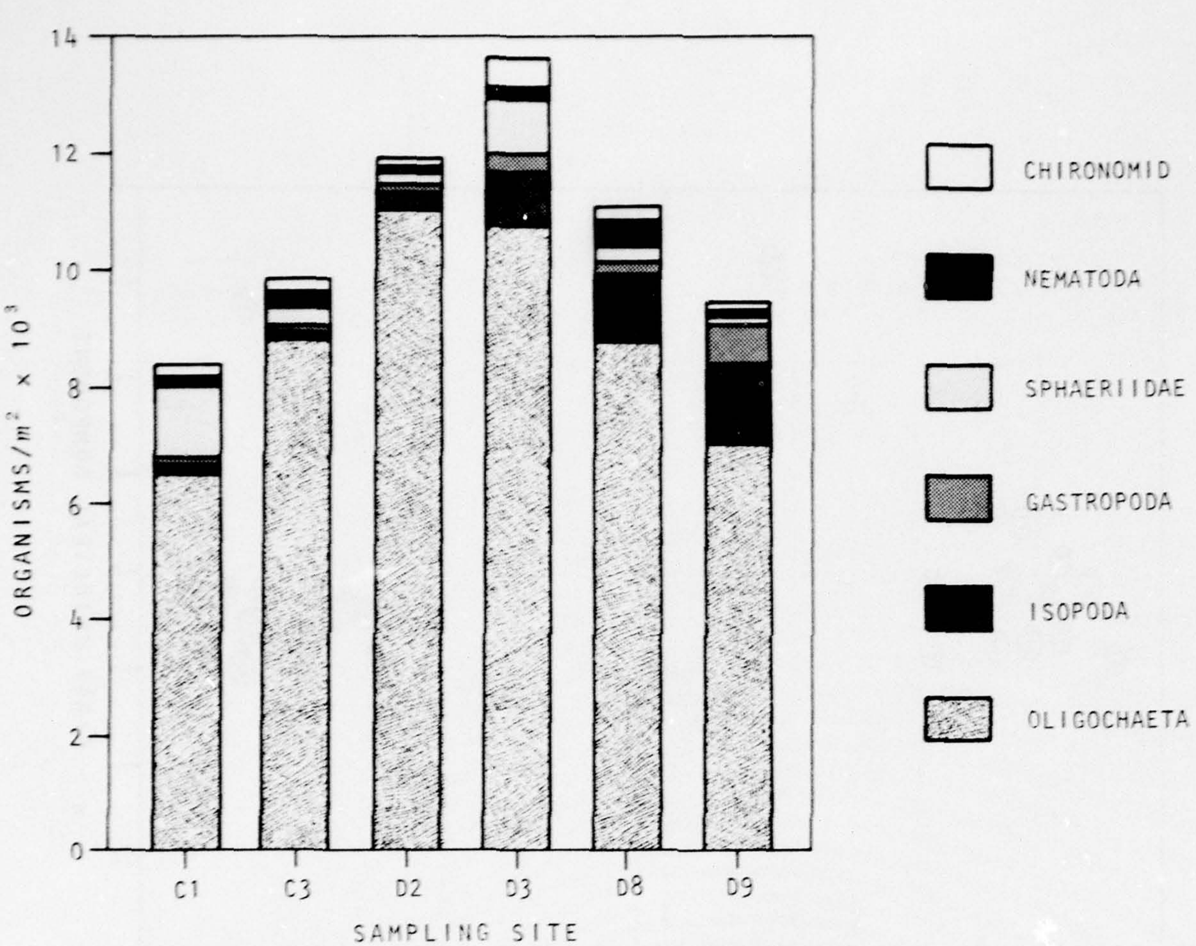

Figure A38. Comparison of benthic macroinvertebrate mean total number and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 prior to disposal, 31 July 1975

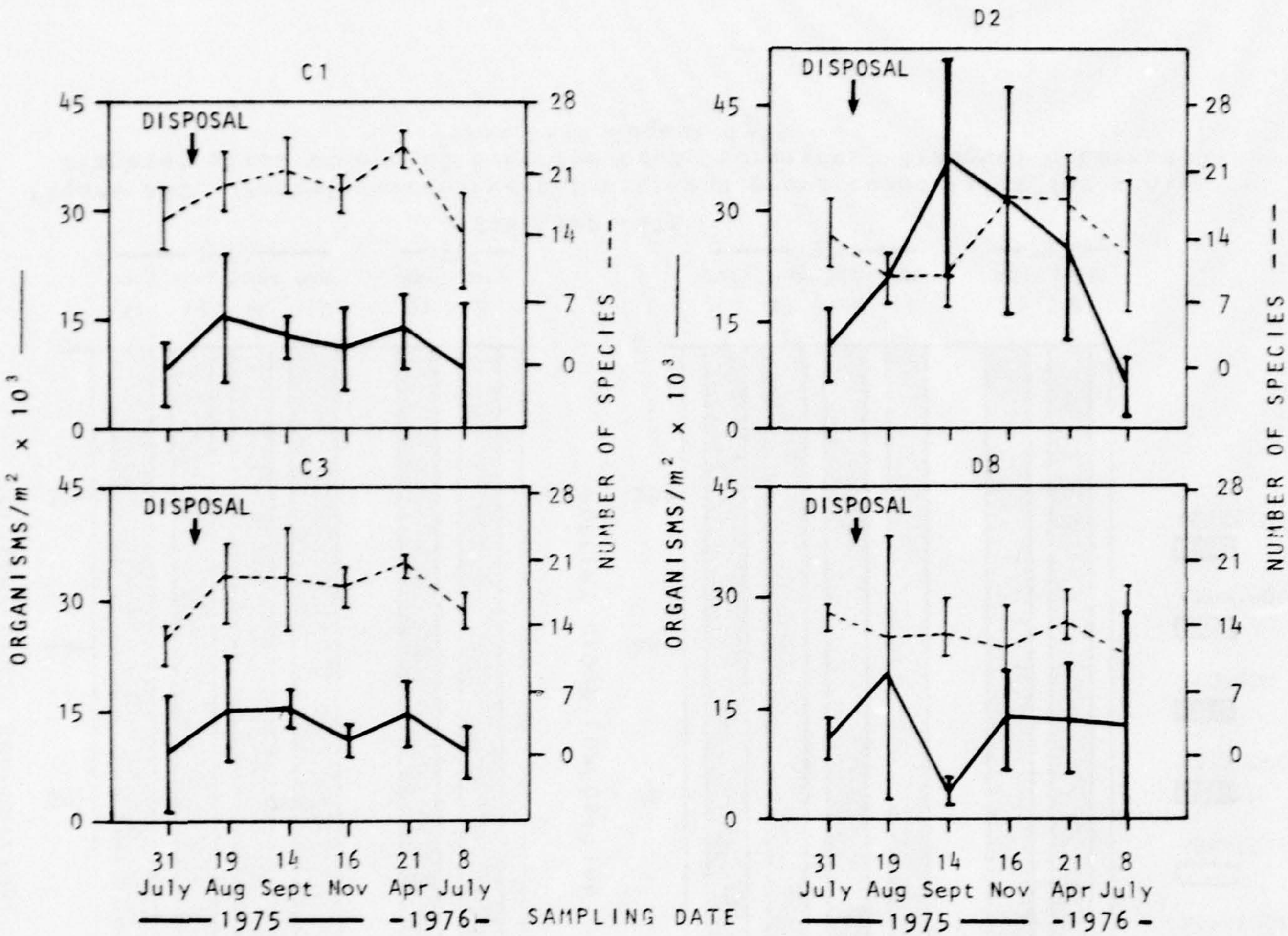

Figure A39. Mean number of species and organisms for the total macrobenthic invertebrate fauna of reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study duration. Disposal occurred 4-14 August 1975. Bars represent 95 percent confidence intervals

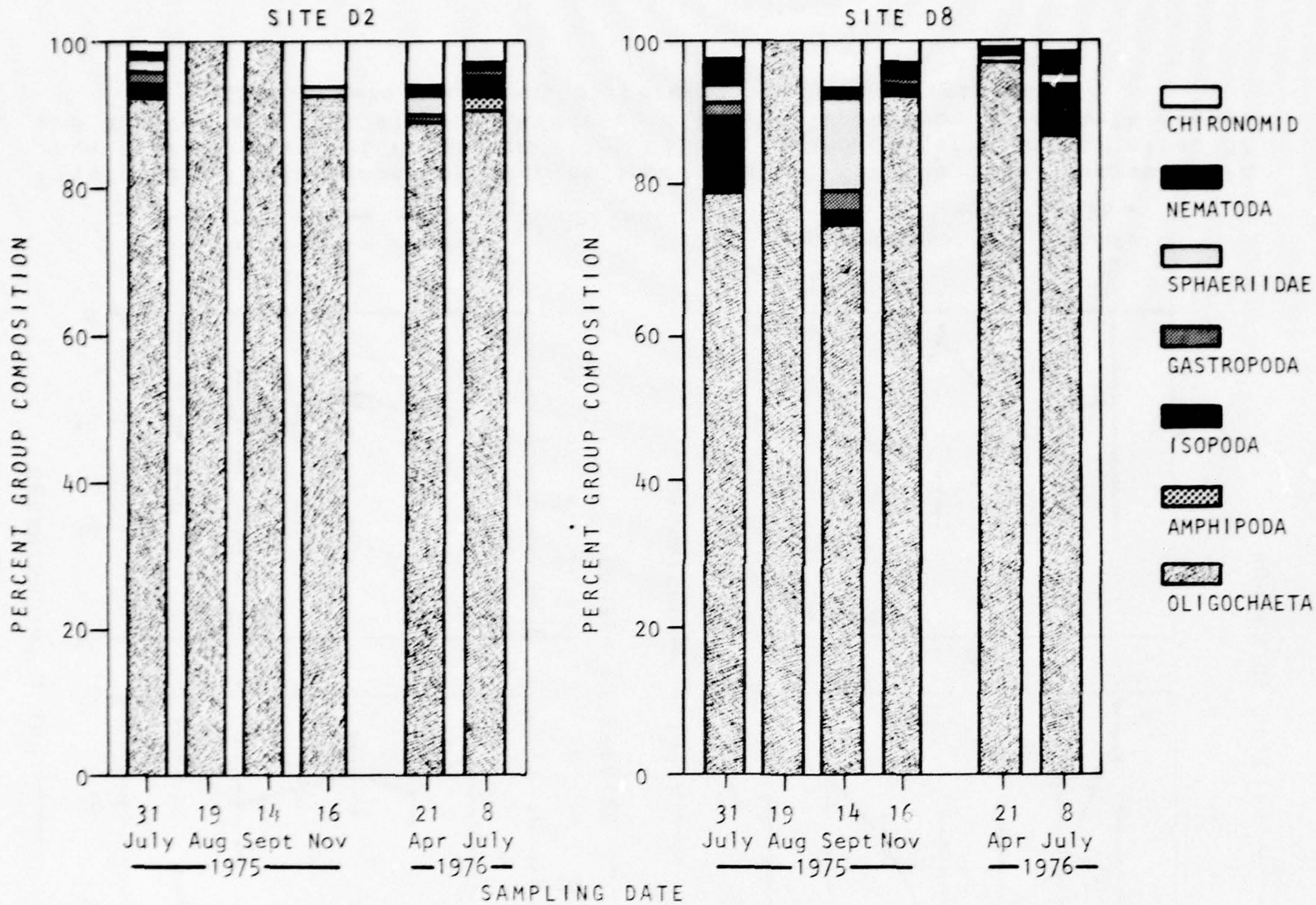

Figure A40. Benthic macroinvertebrate mean group composition for center disposal sites D2 and D8 over the study duration. Disposal occurred from 4-14 August 1975

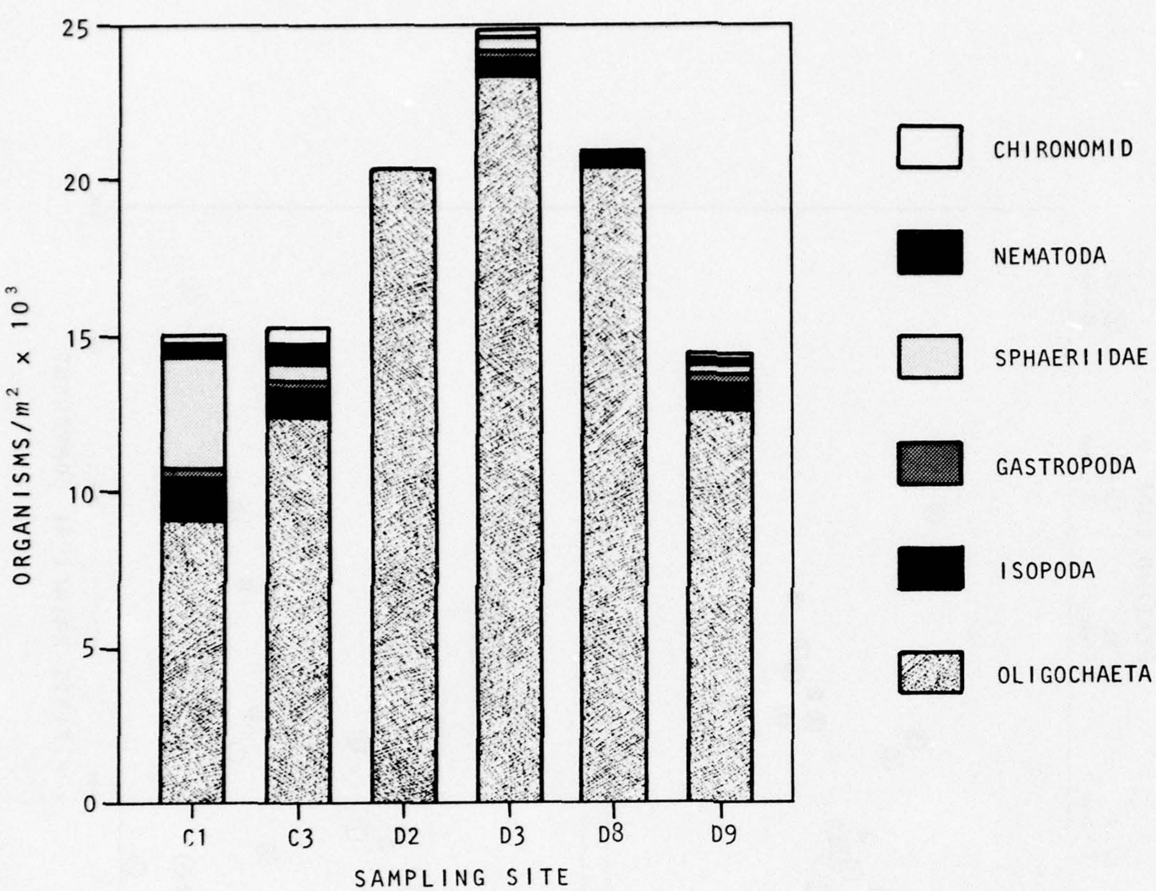

Figure A41. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 sampled 5 days after disposal, 19 August 1975

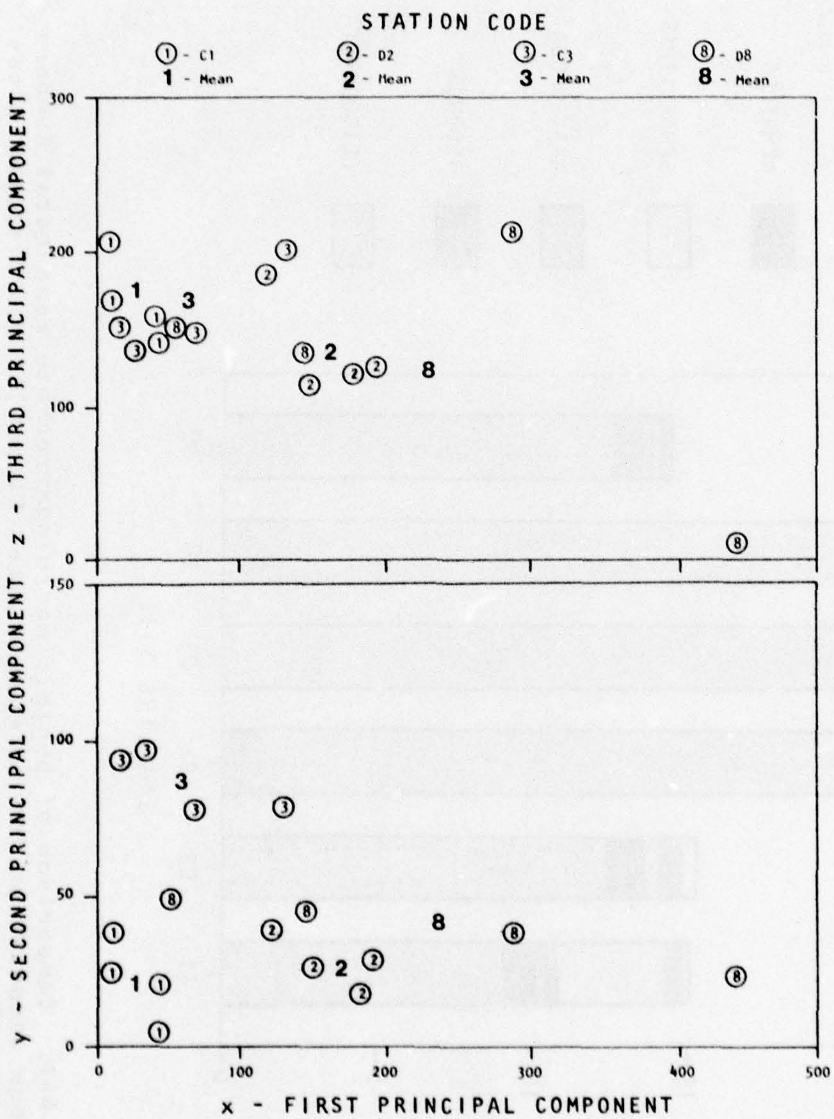

Figure A42. Community ordination (three principal components) of benthic macroinvertebrate data for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 5 days after disposal (19 August 1975). Axis values are in ordination units while distance between points reflects community similarity

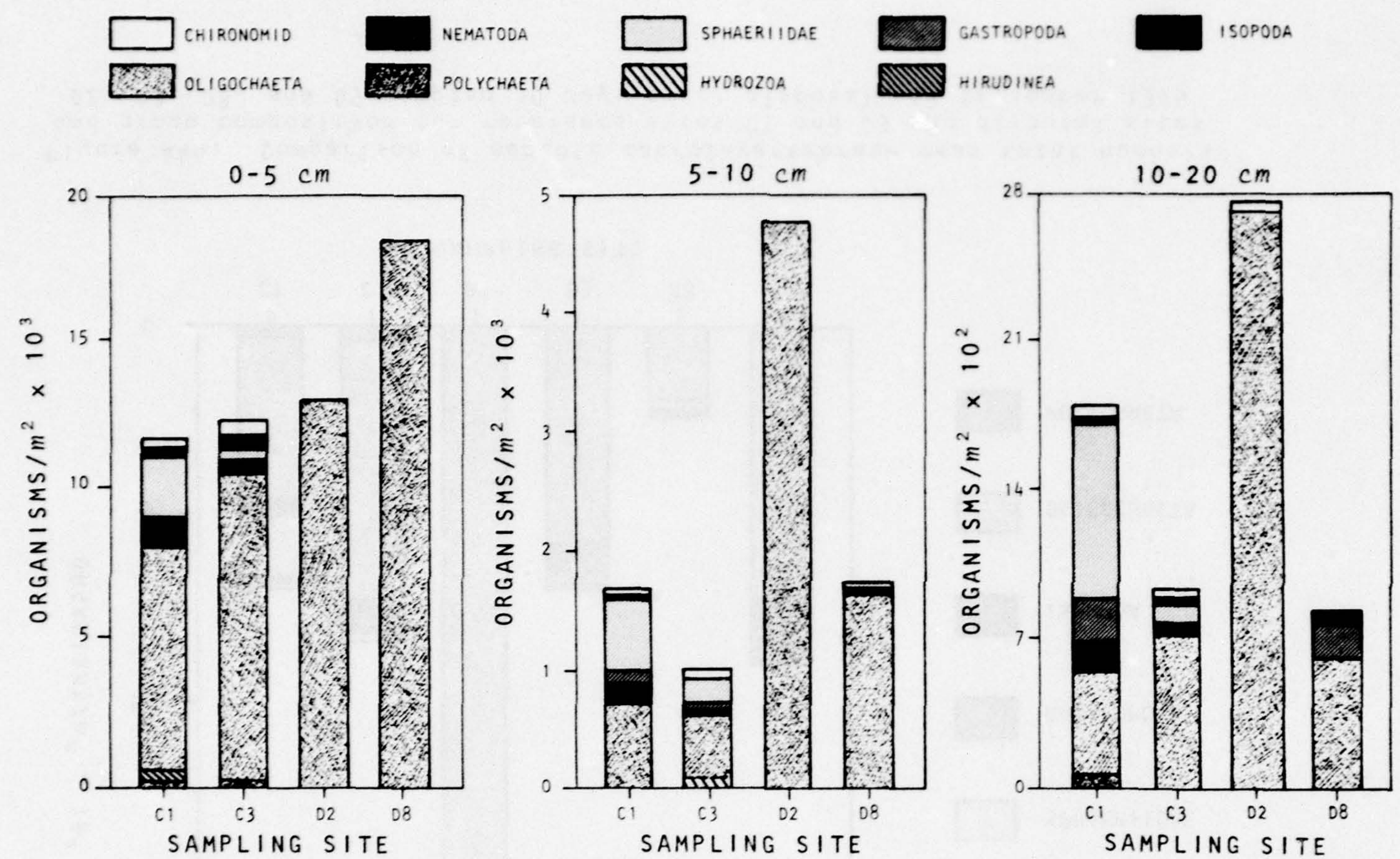

Figure A43. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 5 days after disposal, 19 August 1975

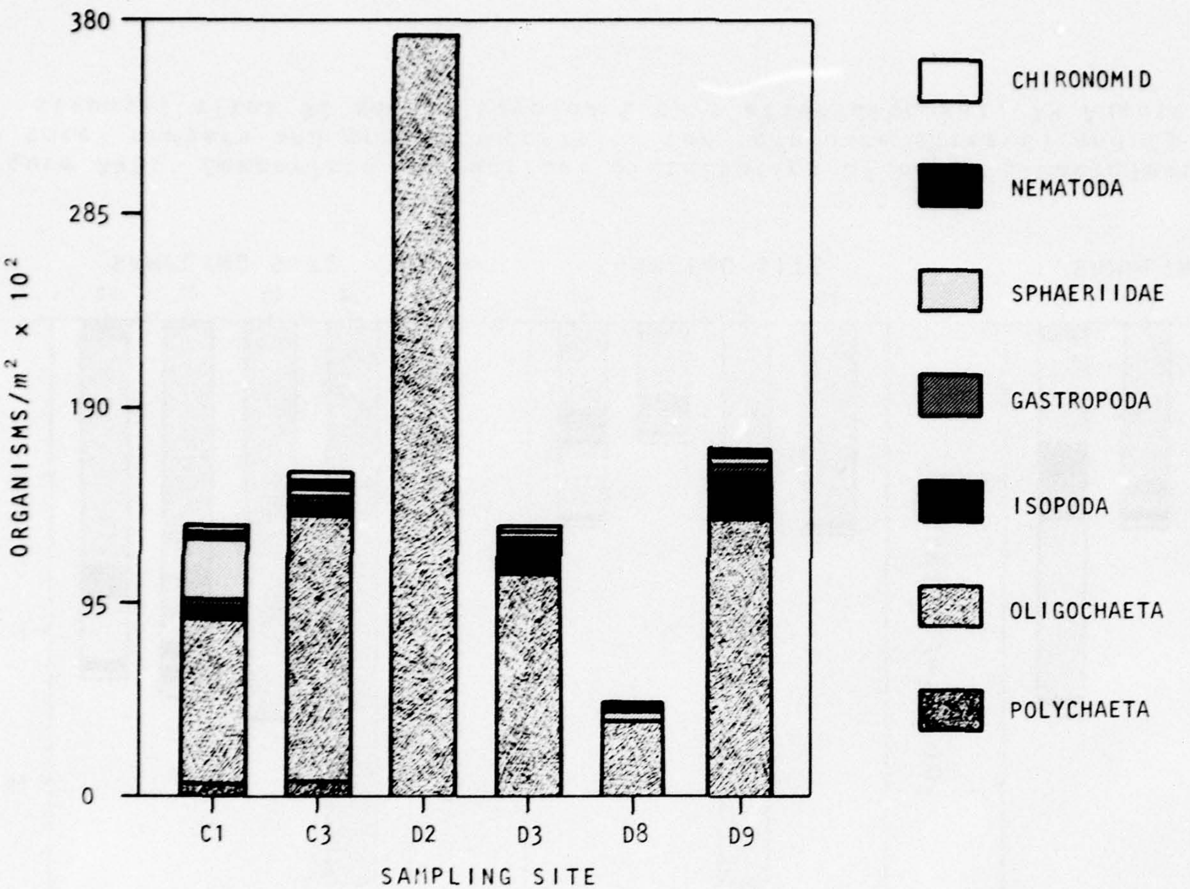

Figure A44. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 sampled 30 days after disposal, 14 September 1975

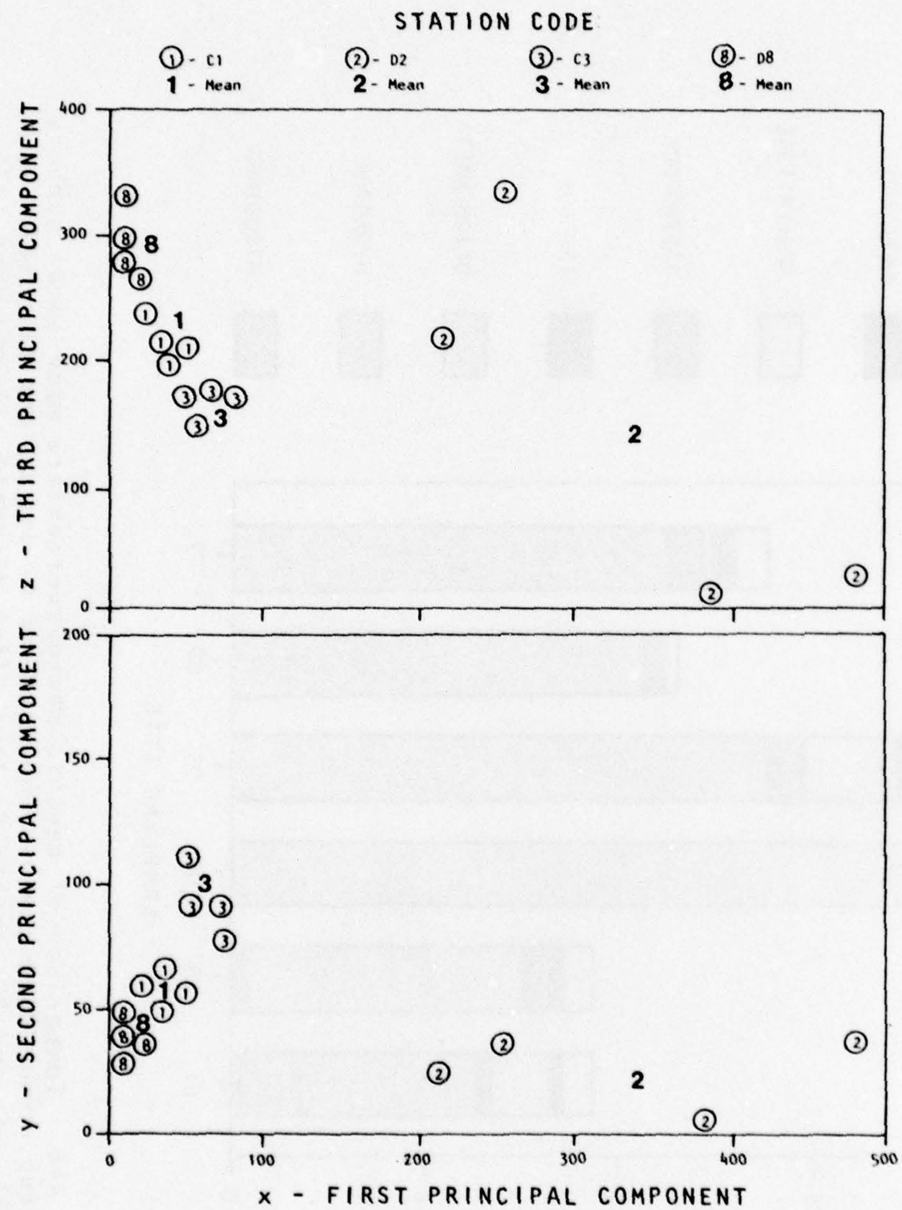

Figure A45. Community ordination (three principal components) of benthic macroinvertebrate data for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 30 days after disposal, 14 September 1975. Axis values are in ordination units while distance between points reflects community similarity

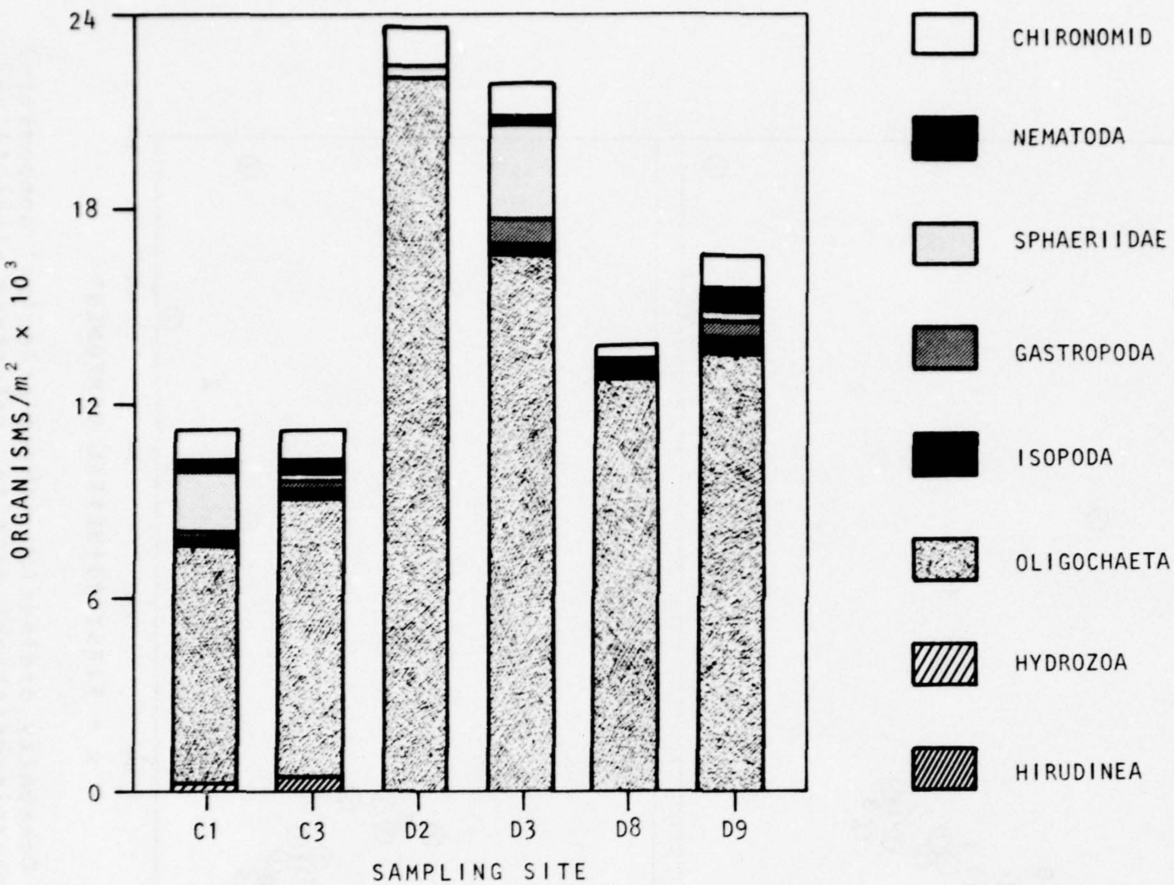

Figure A46. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 sampled 90 days after disposal, 16 November 1975

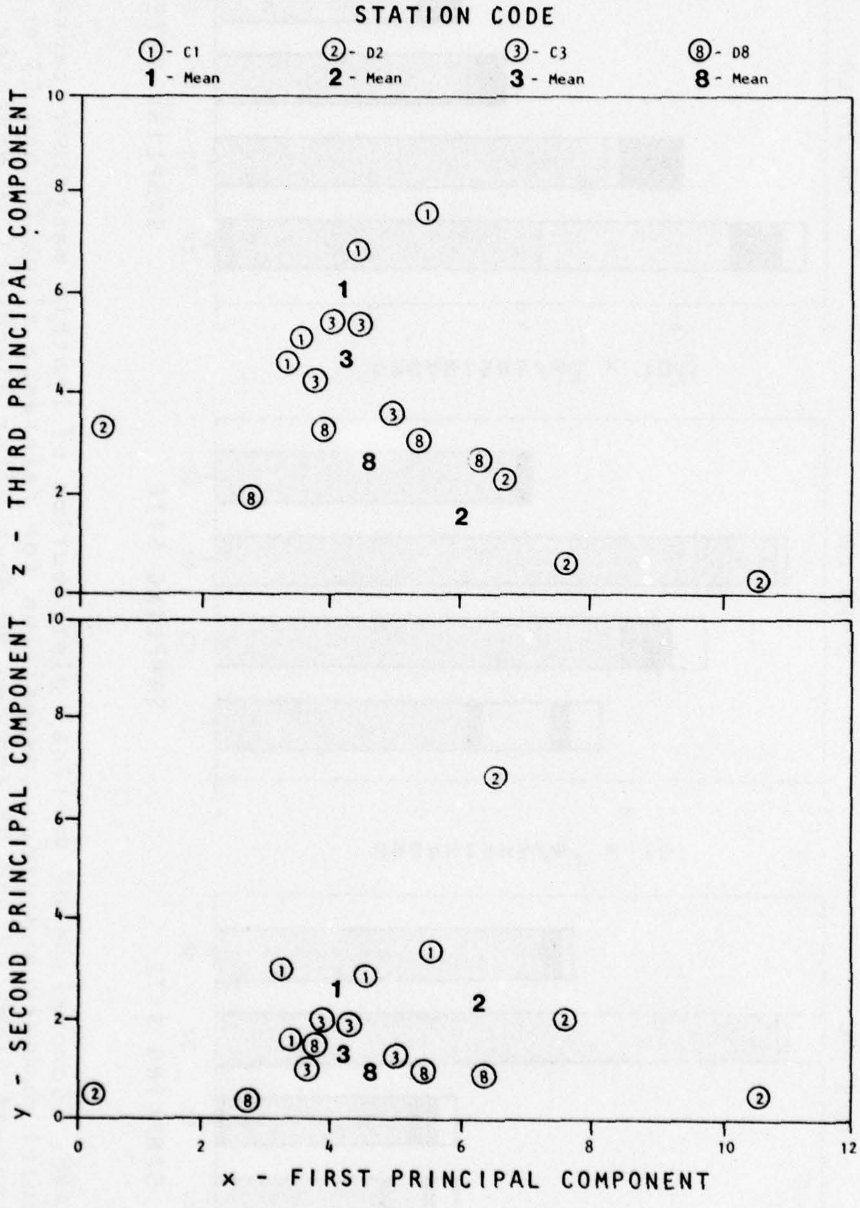

Figure A47. Community ordination (three principal components) of benthic macroinvertebrate logarithmic data for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 90 days after disposal, 16 November 1975. Axis values are in ordination units while distance between points reflects community similarity

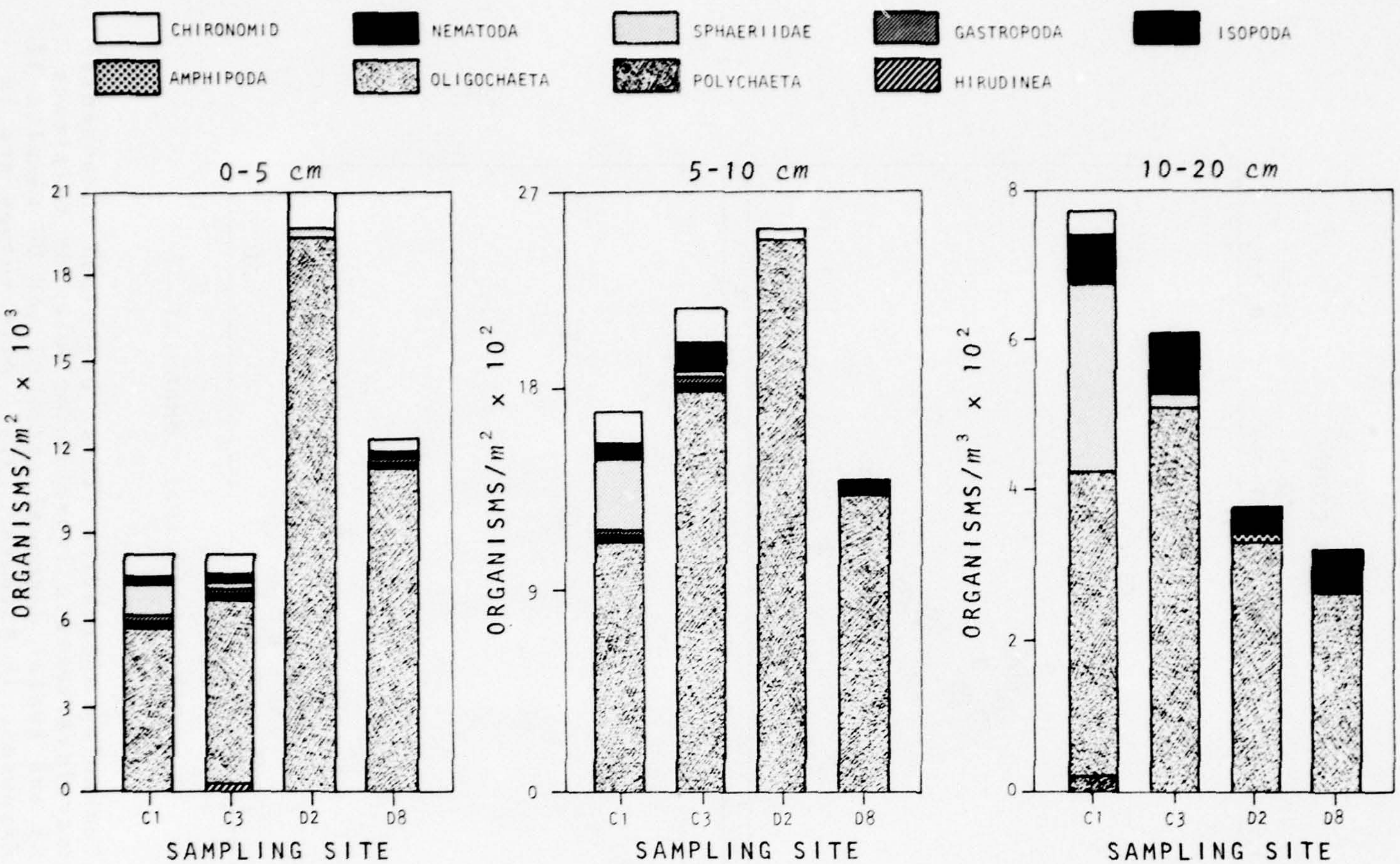

Figure A48. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 90 days after disposal, 16 November 1975

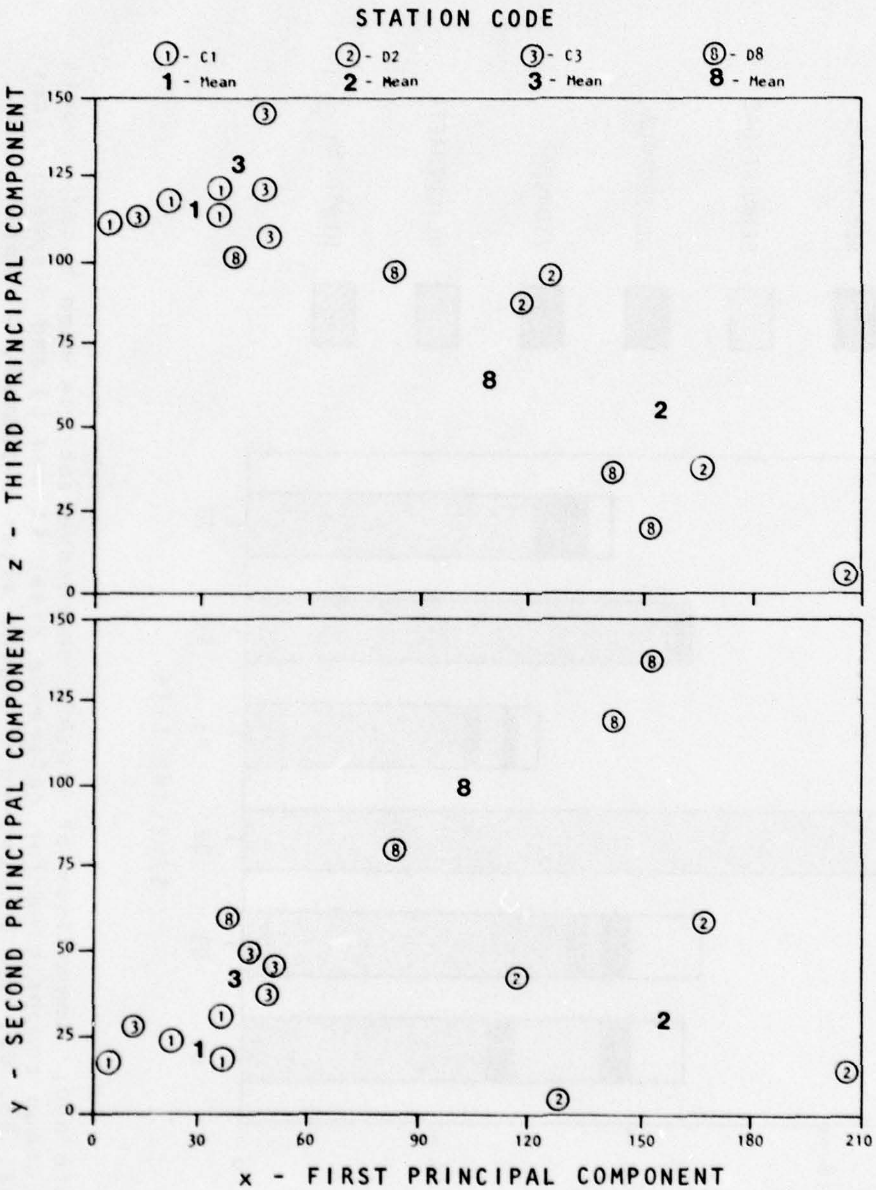

Figure A49. Community ordination (three principal components) of benthic macroinvertebrate data for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 8 months after disposal, 21 April 1976. Axis values are in ordination units while distance between points reflects community similarity

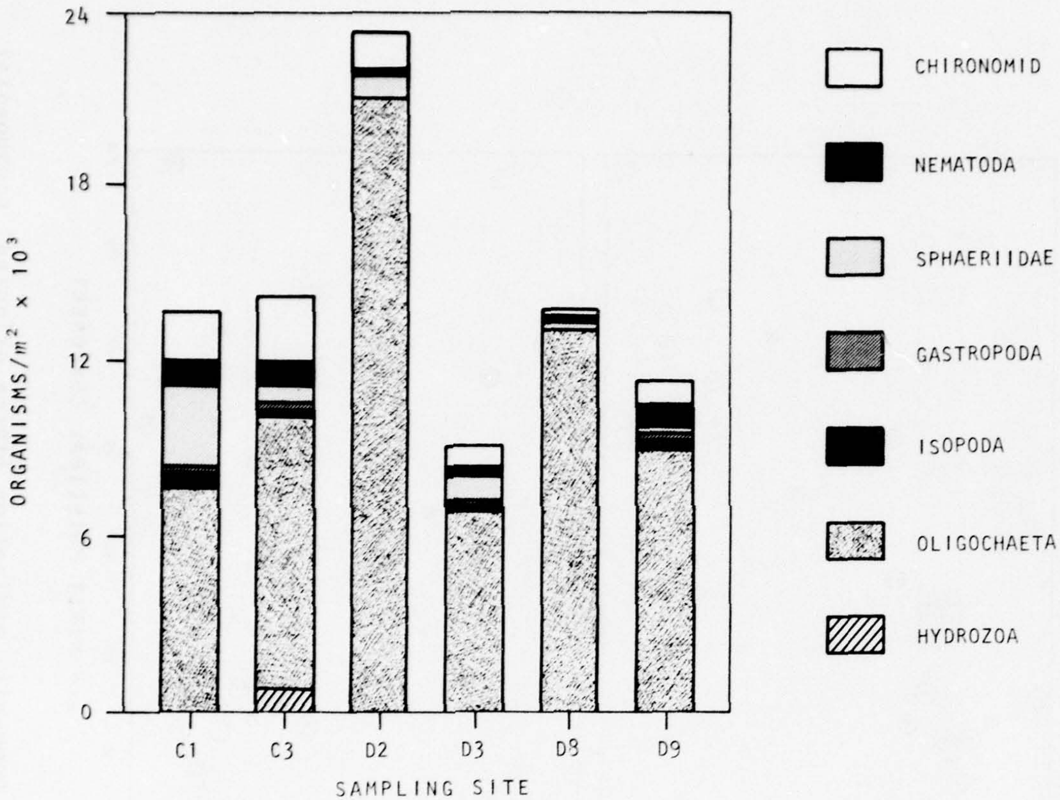

Figure A50, Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 sampled 8 months after disposal, 21 April 1976

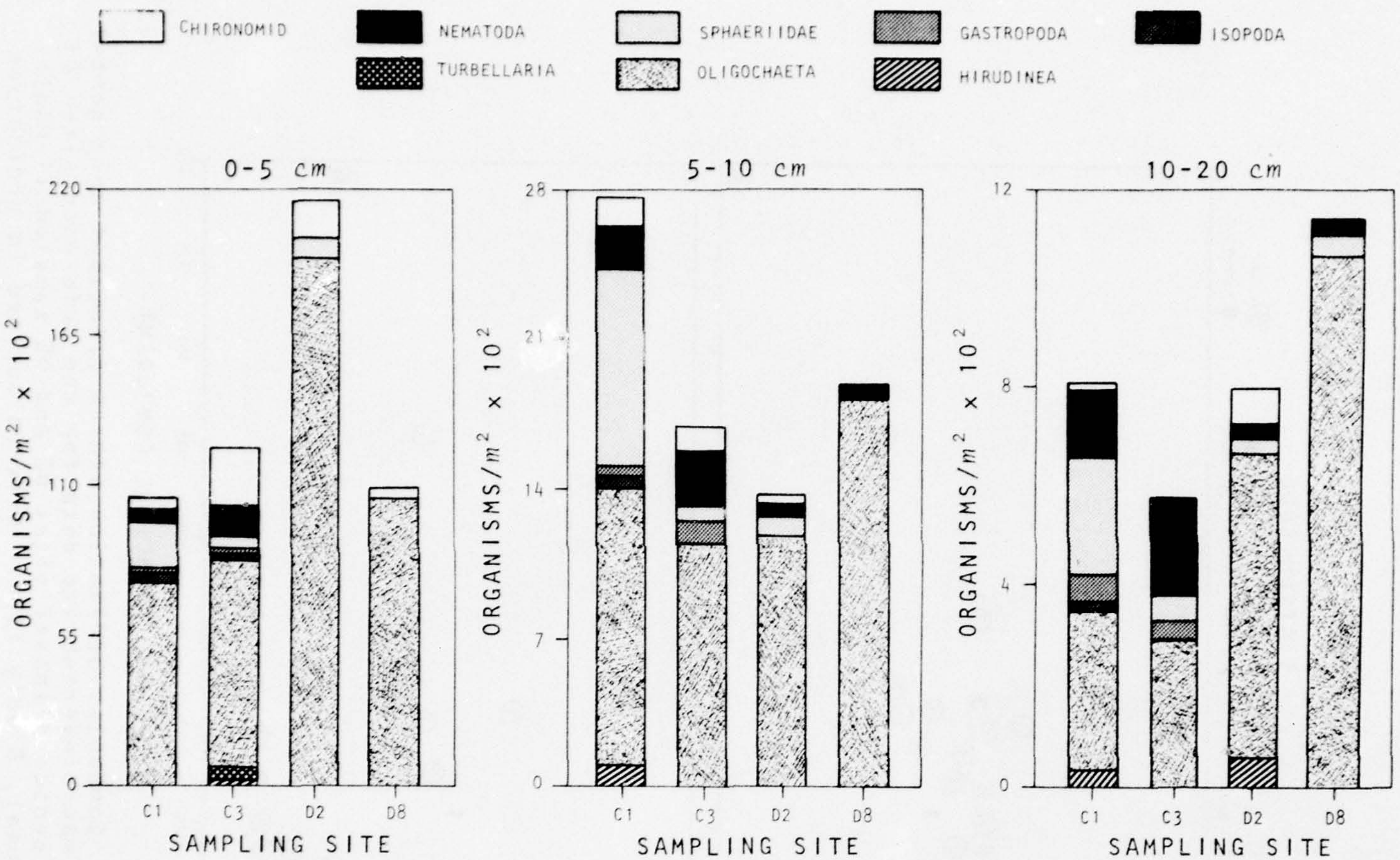

Figure A51. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 8 months after disposal, 21 April 1976

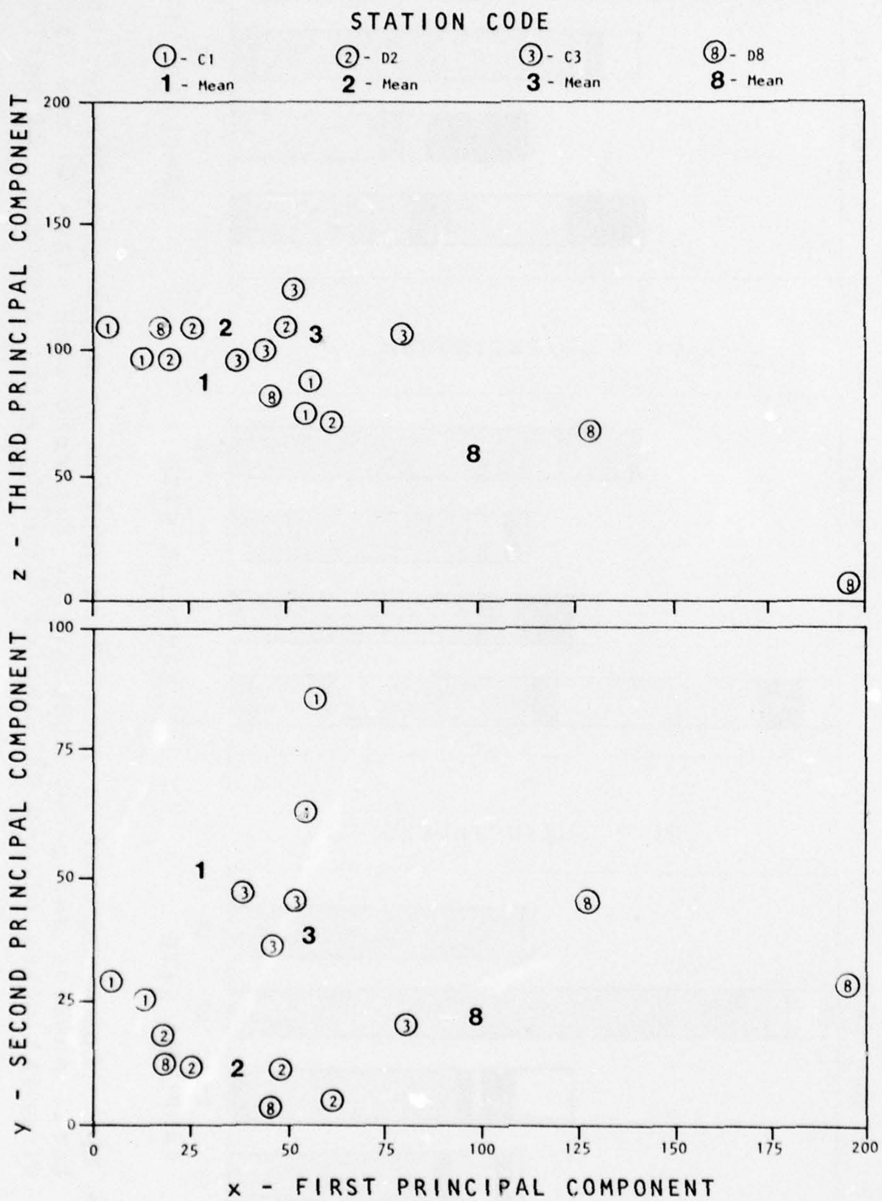

Figure A52. Community ordination (three principal components) of benthic macroinvertebrate data for the reference sites C1 and C3 and center disposal sites D2 and D8 sampled 11 months after disposal, 8 July 1976. Axis values are in ordination units while distance between points reflects community similarity

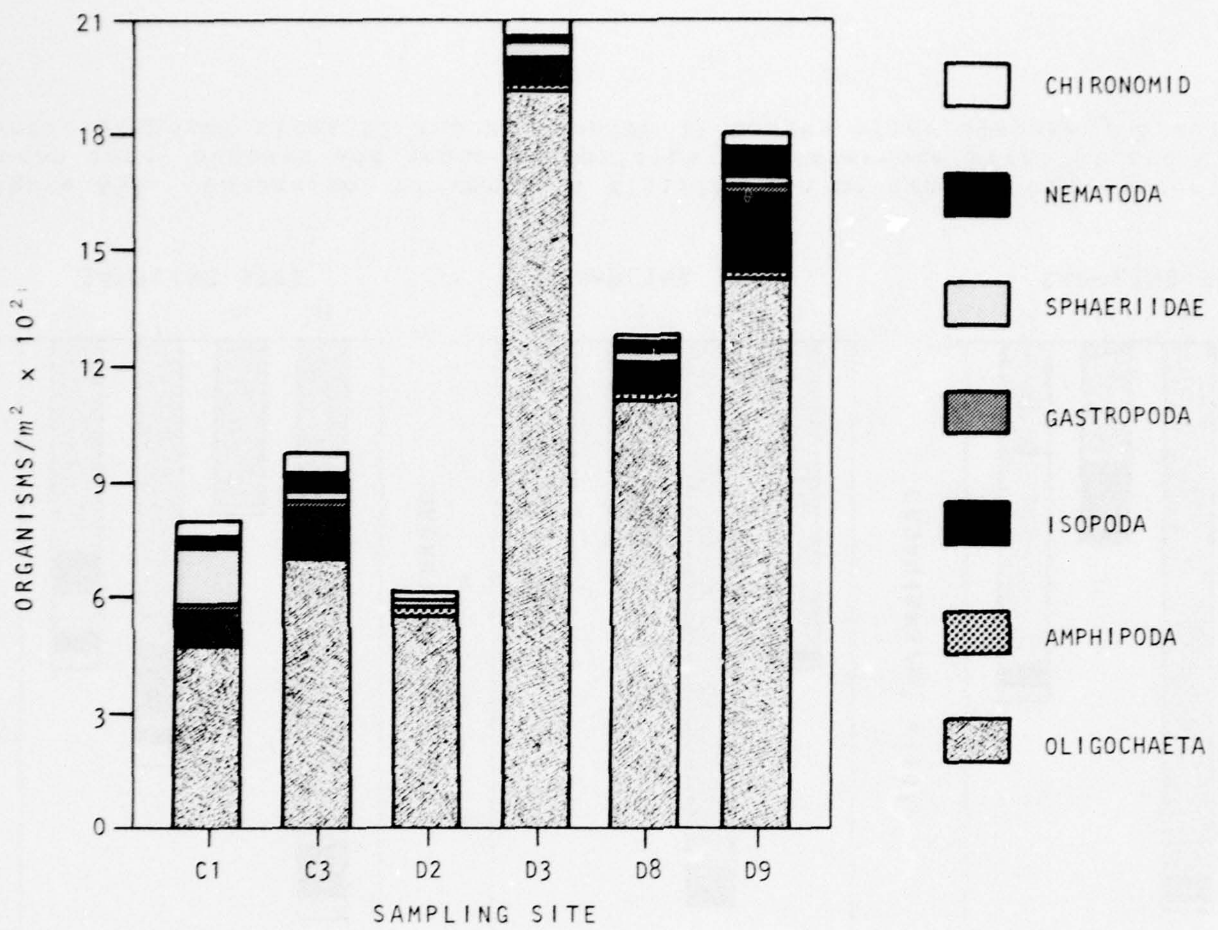

Figure A53. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites D2, D3, D8, and D9 sampled 11 months after disposal (8 July 1976)

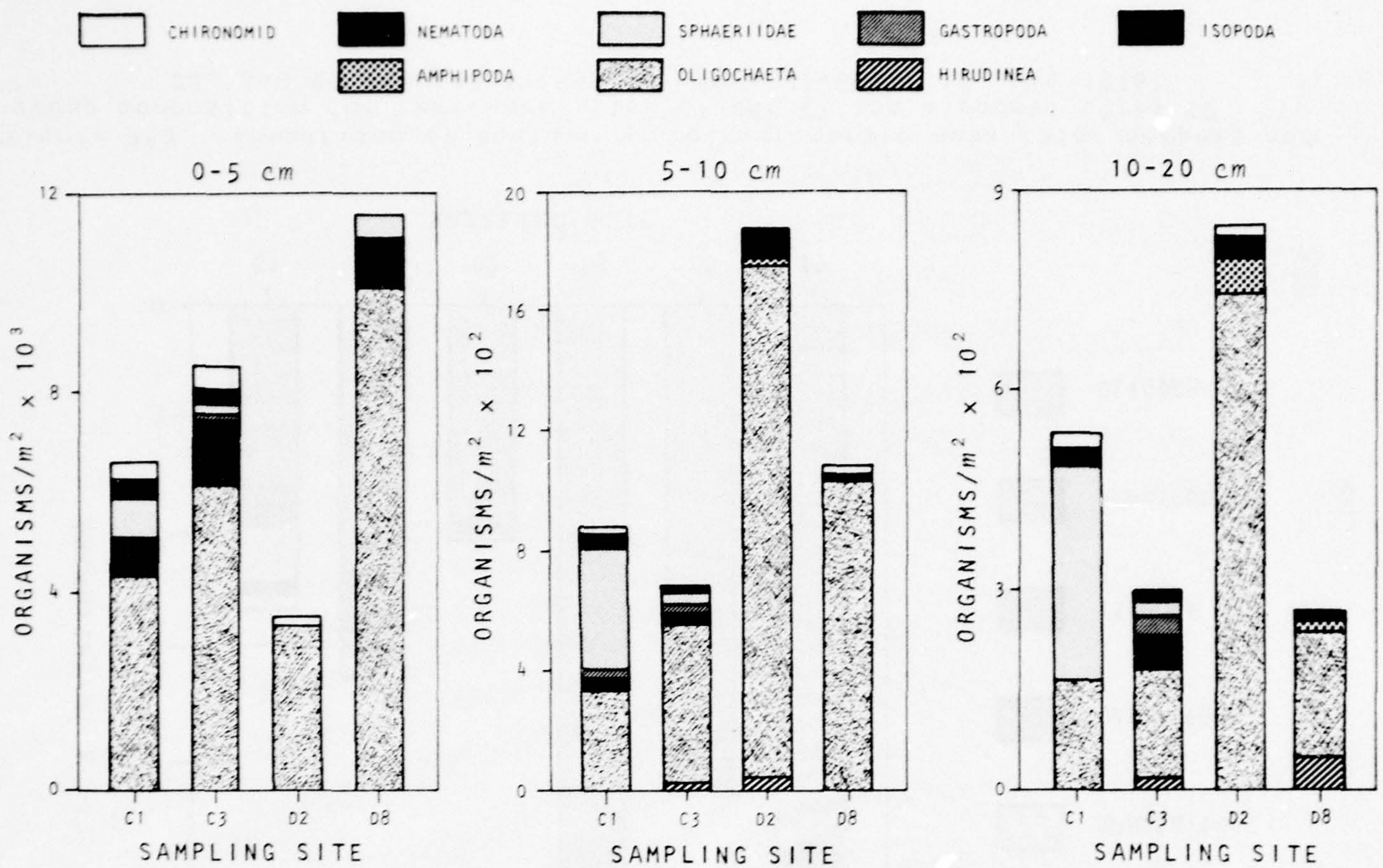

Figure A54. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and center disposal sites D2 and D8 sampled 11 months after disposal, 8 July 1976

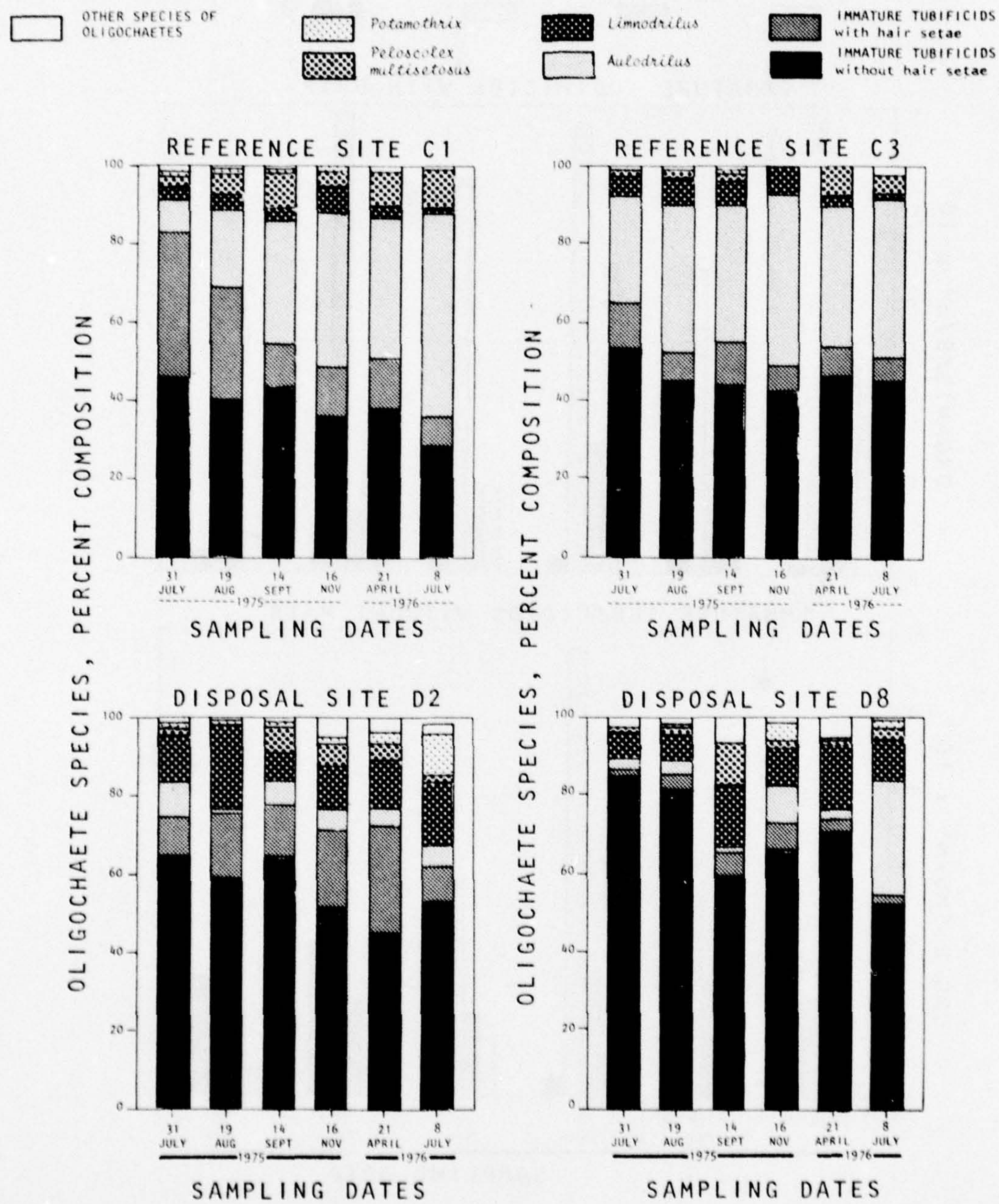

Figure A55. Mean composition of major oligochaete species over the study duration for the reference sites C1 and C3 and center disposal sites D2 and D8. Disposal occurred 4-14 August 1976

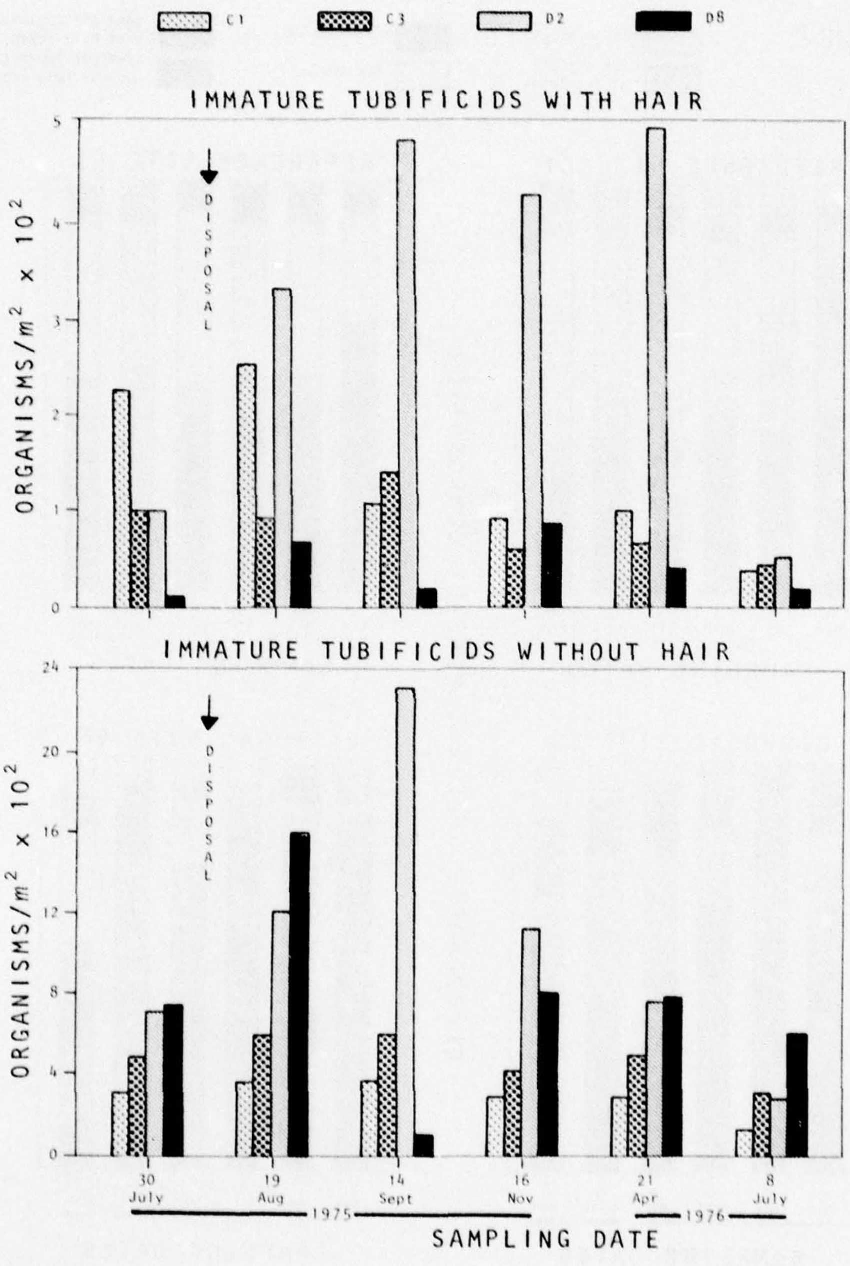

Figure A56. Mean number of immature tubificids with hair setae and without hair setae at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975 (arrow)

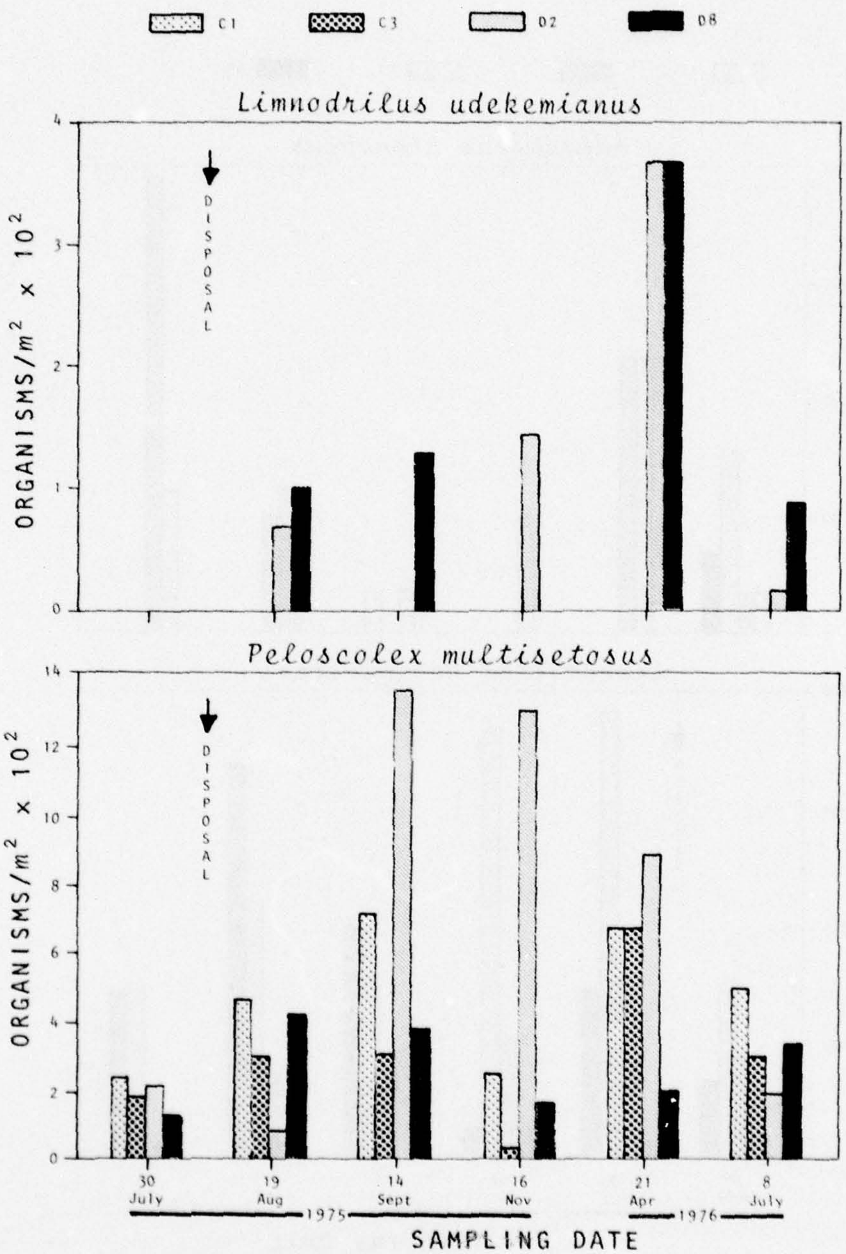

Figure A57. Mean number of *Limnodrilus udekemianus* and *Peloscolex multisetosus* at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975 (arrow)

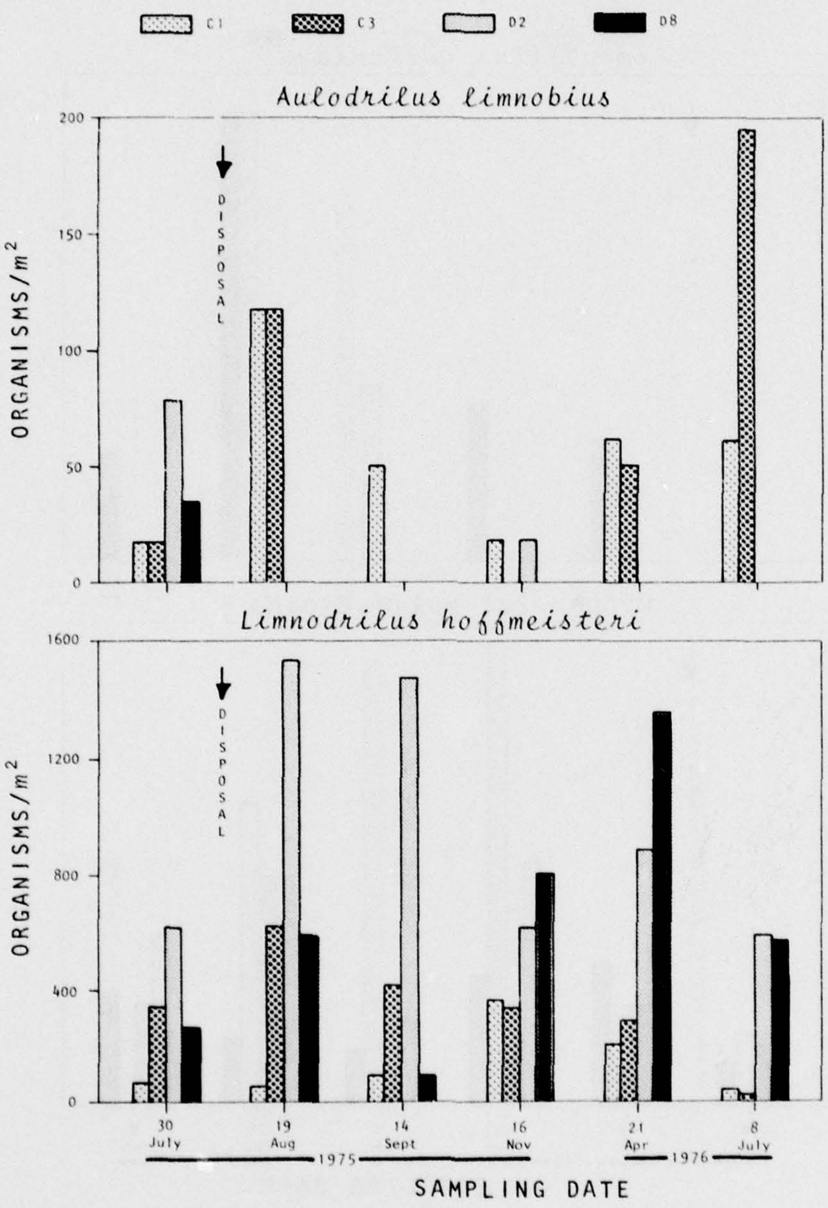

Figure A58. Mean number of *Aulodrilus limnobius* and *Limnodrilus hoffmeisteri* at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975 (arrow)

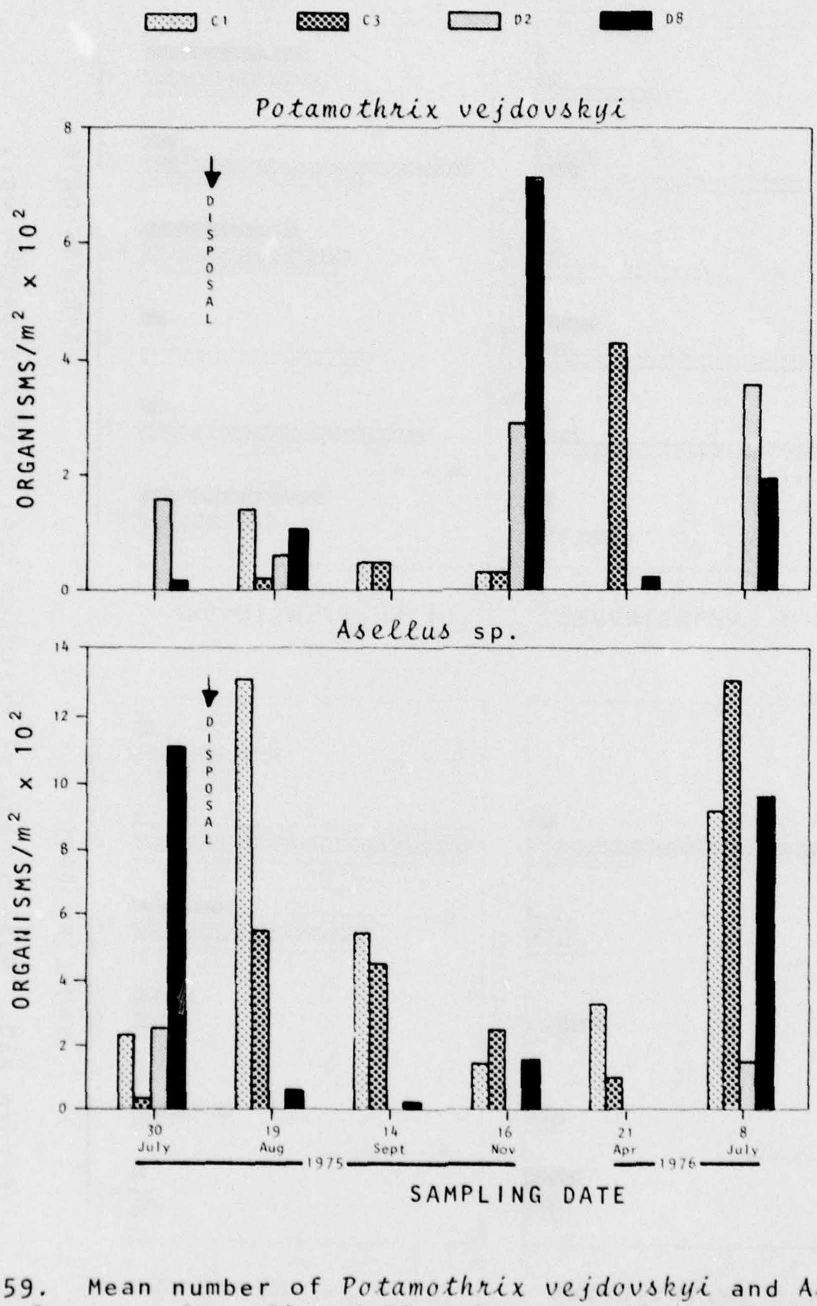

Figure A59. Mean number of *Potamothrix vejdovskyi* and *Asellus* sp. at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975 (arrow)

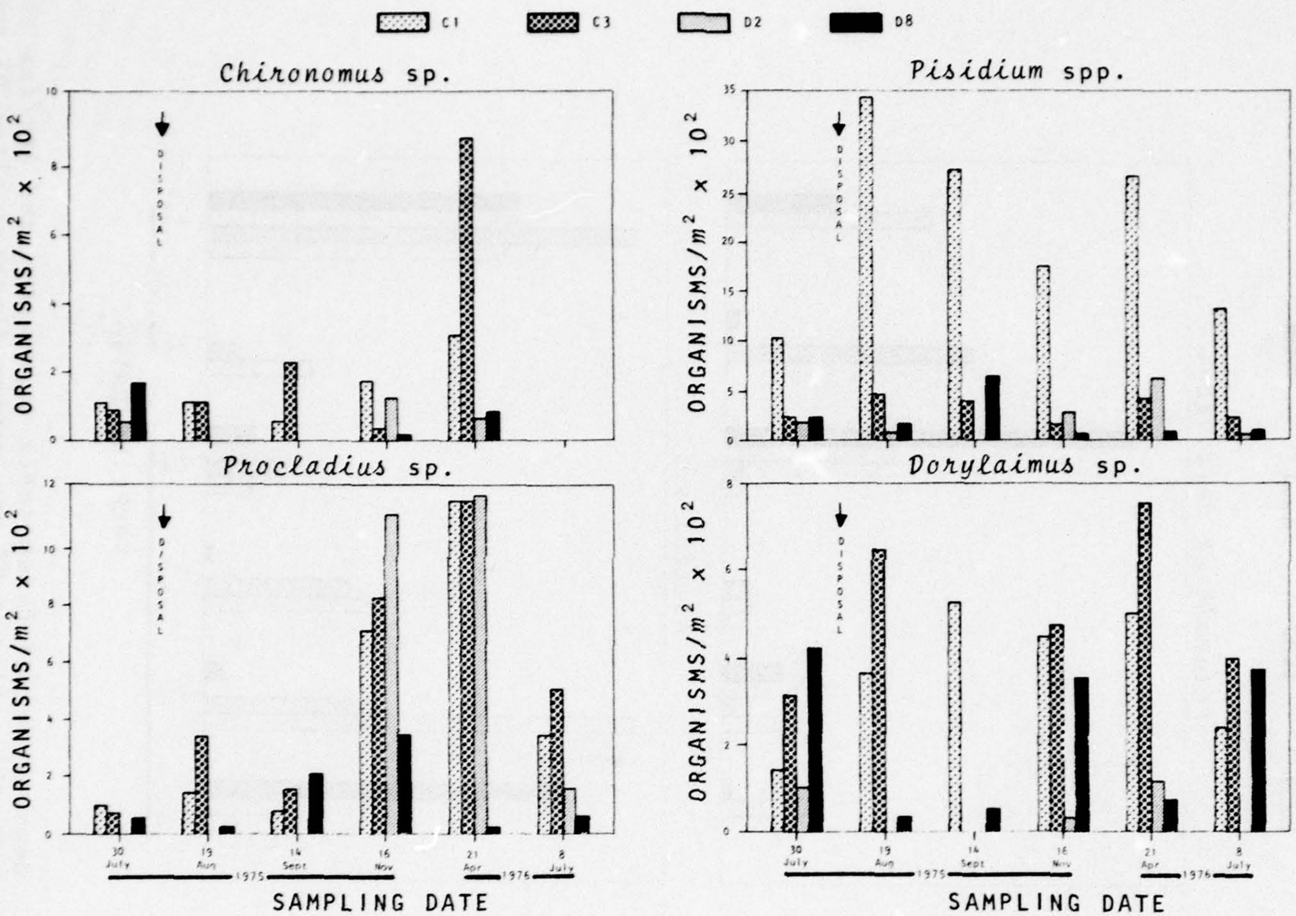

Figure A60. Mean number of *Pisidium* spp., and *Dorylaimus* sp., *Chironomus* sp., and *Procladius* sp. at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975 (arrow)

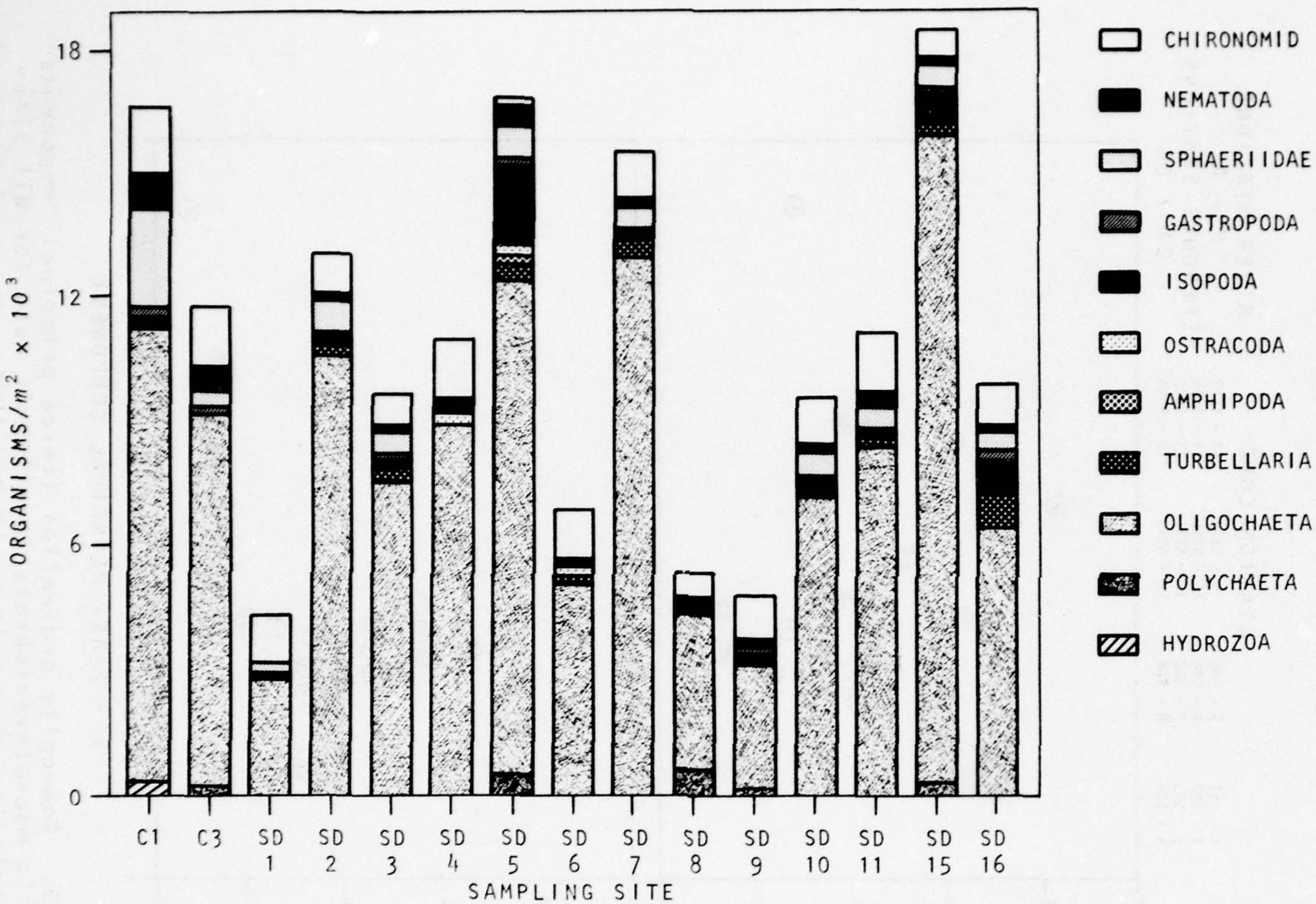

Figure A61. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites SD1-SD11, SD15-SD16 prior to disposal, 15 May 1976

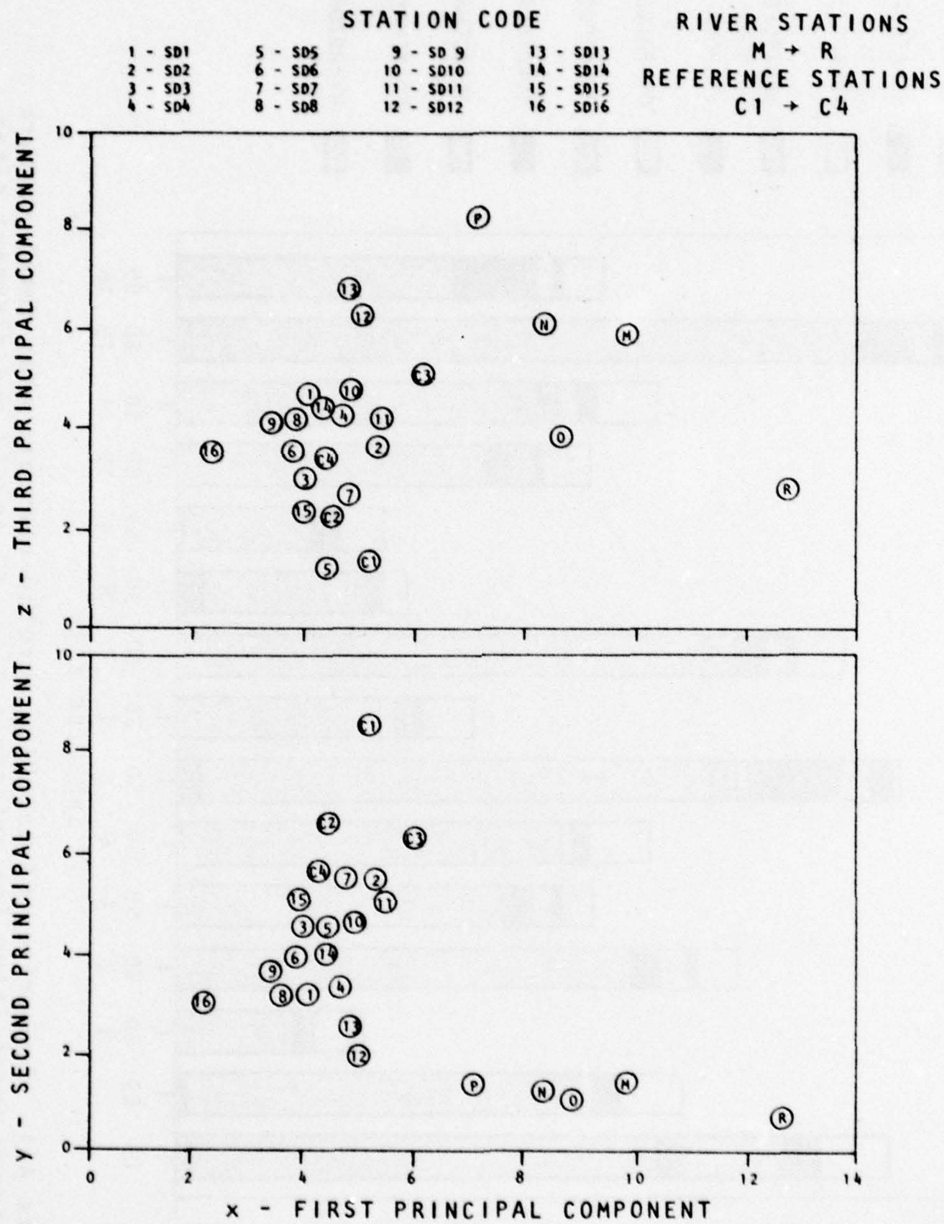

Figure A62. Community ordination (three principal components) of benthic macroinvertebrate logarithmic data for all sites sampled, including river sites, 15 May 1976. Axis values are in ordination units while distance between sites reflects community similarity

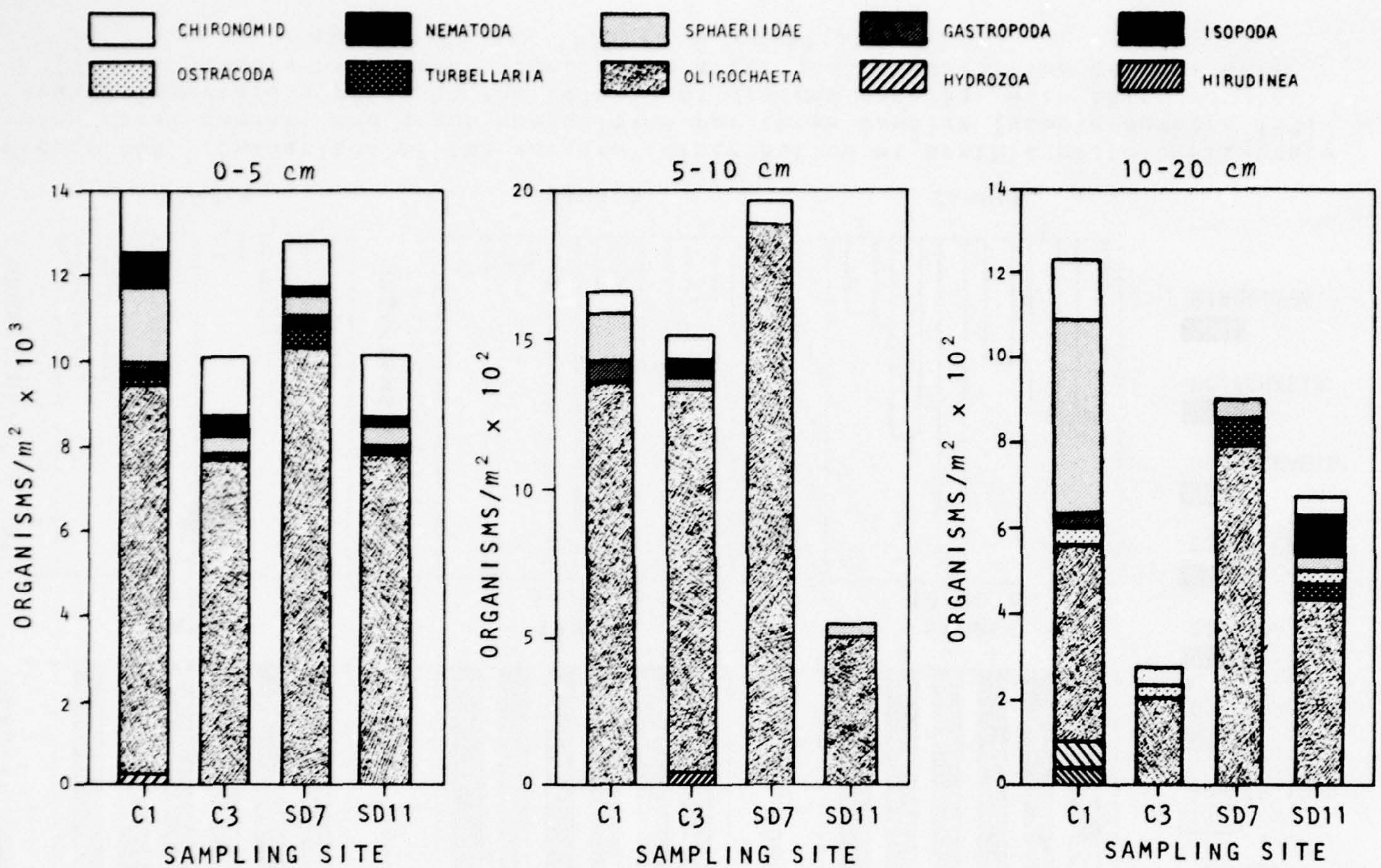

Figure A63. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for the reference sites C1 and C3 and disposal sites SD7 and SD11 prior to disposal, 15 May 1976

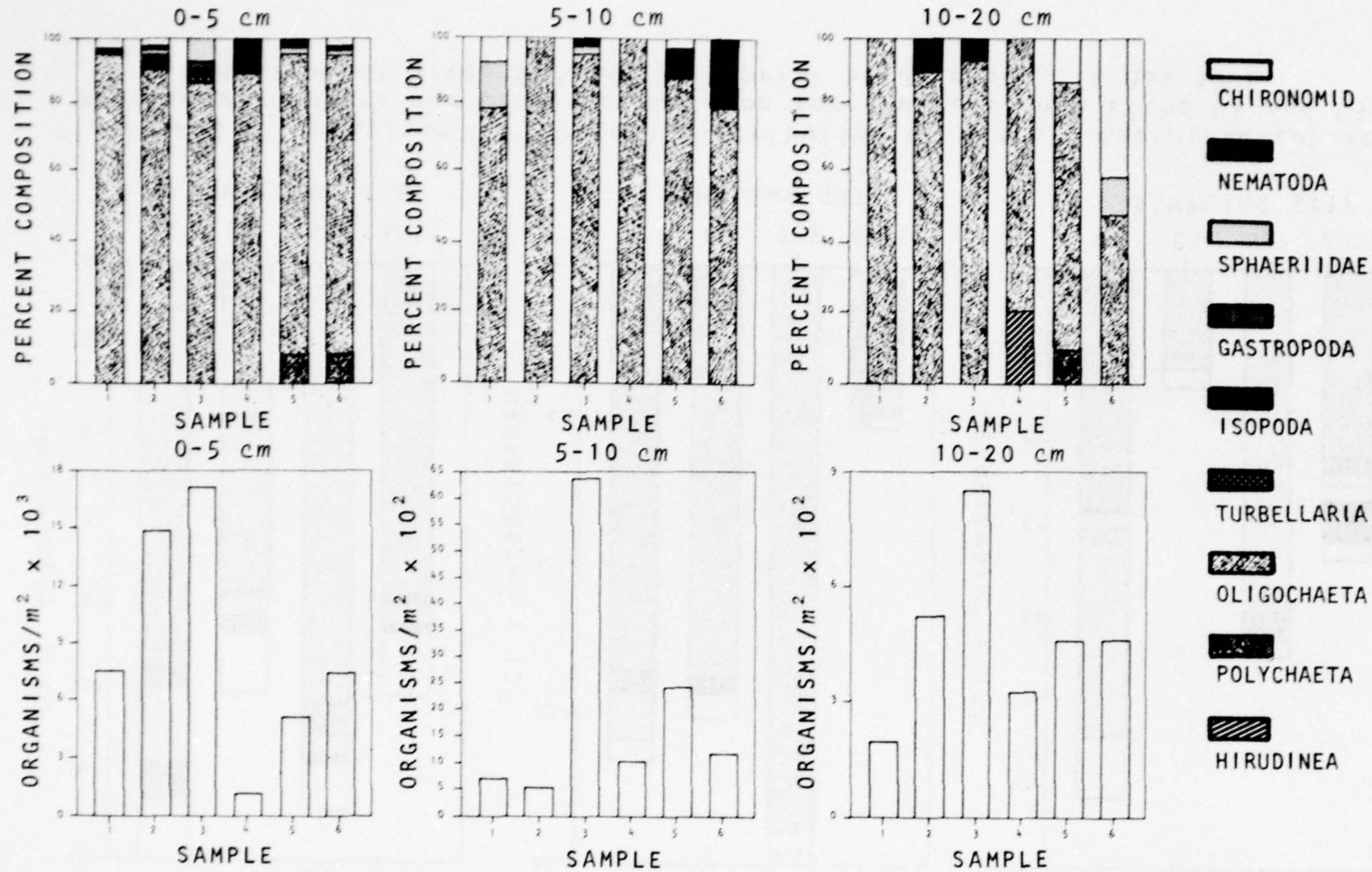

Figure A64. Comparison of the vertical distribution of benthic macroinvertebrate mean total numbers and group composition for three samples (sample numbers 1-3) taken immediately prior to the release of dredged material with three samples (sample numbers 4-6) taken immediately after the release. The samples were taken on 25 May 1976 at disposal site SD10

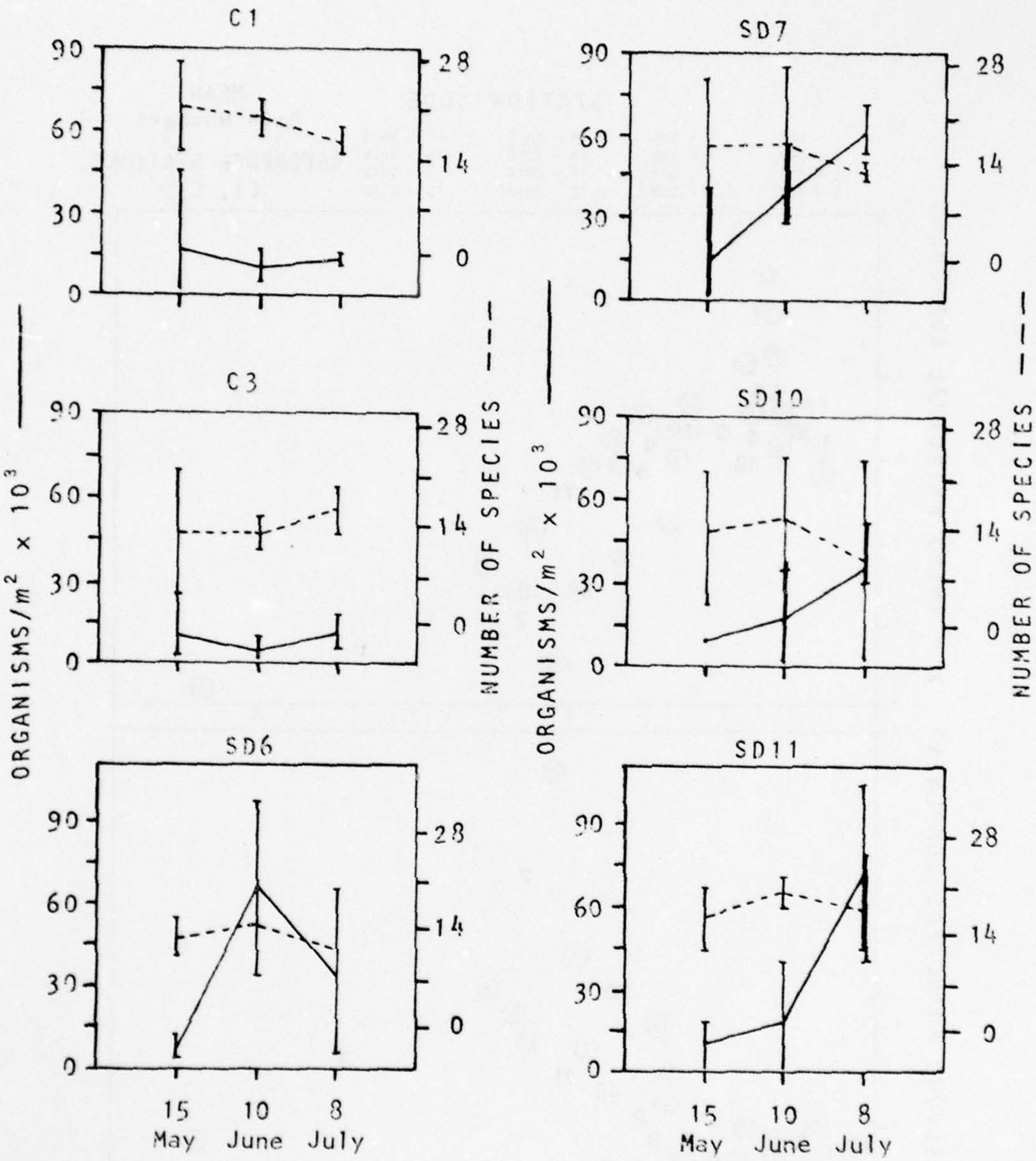

Figure A65. Mean number of species and organisms for the total macrobenthic invertebrate fauna of the reference sites C1 and C3 and center disposal sites SD6, SD7, SD10, and SD11 over the 1976 disposal study. Disposal occurred 24-26 May 1976. Bars represent 95 percent confidence intervals

AD-A061 317   STATE UNIV OF NEW YORK COLL AT BUFFALO GREAT LAKES LAB   F/G 13/3
AQUATIC DISPOSAL FIELD INVESTIGATIONS, ASHTABULA RIVER DISPOSAL--ETC(U)
JUL 78 R A SWEENEY   DACW39-75-C-0110

UNCLASSIFIED   WES-D-77-42-APP-A   NL

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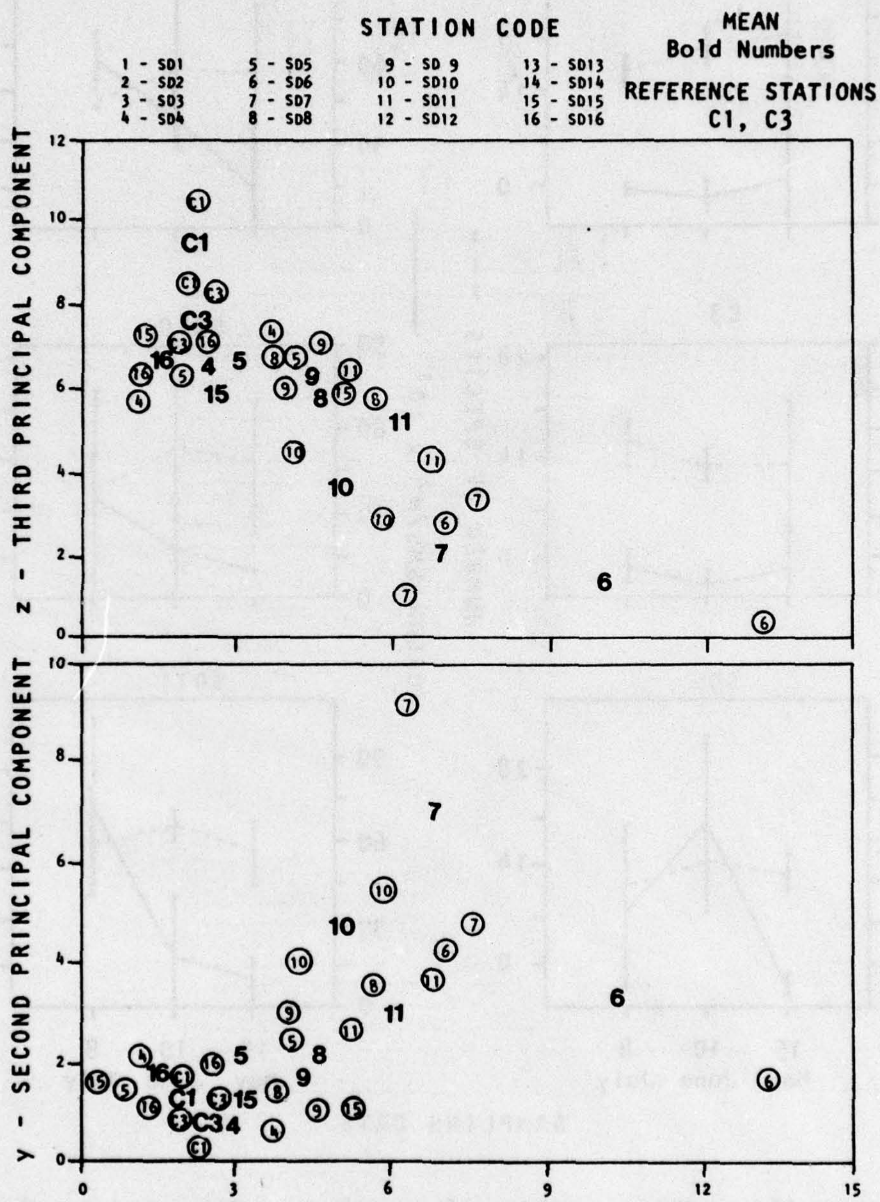

Figure A66. Community ordination (three principal components) of benthic macroinvertebrate logarithmic data for all sites sampled 5 days after disposal, 10 June 1976. Axis values are in ordination units while distance between sites reflects community similarity

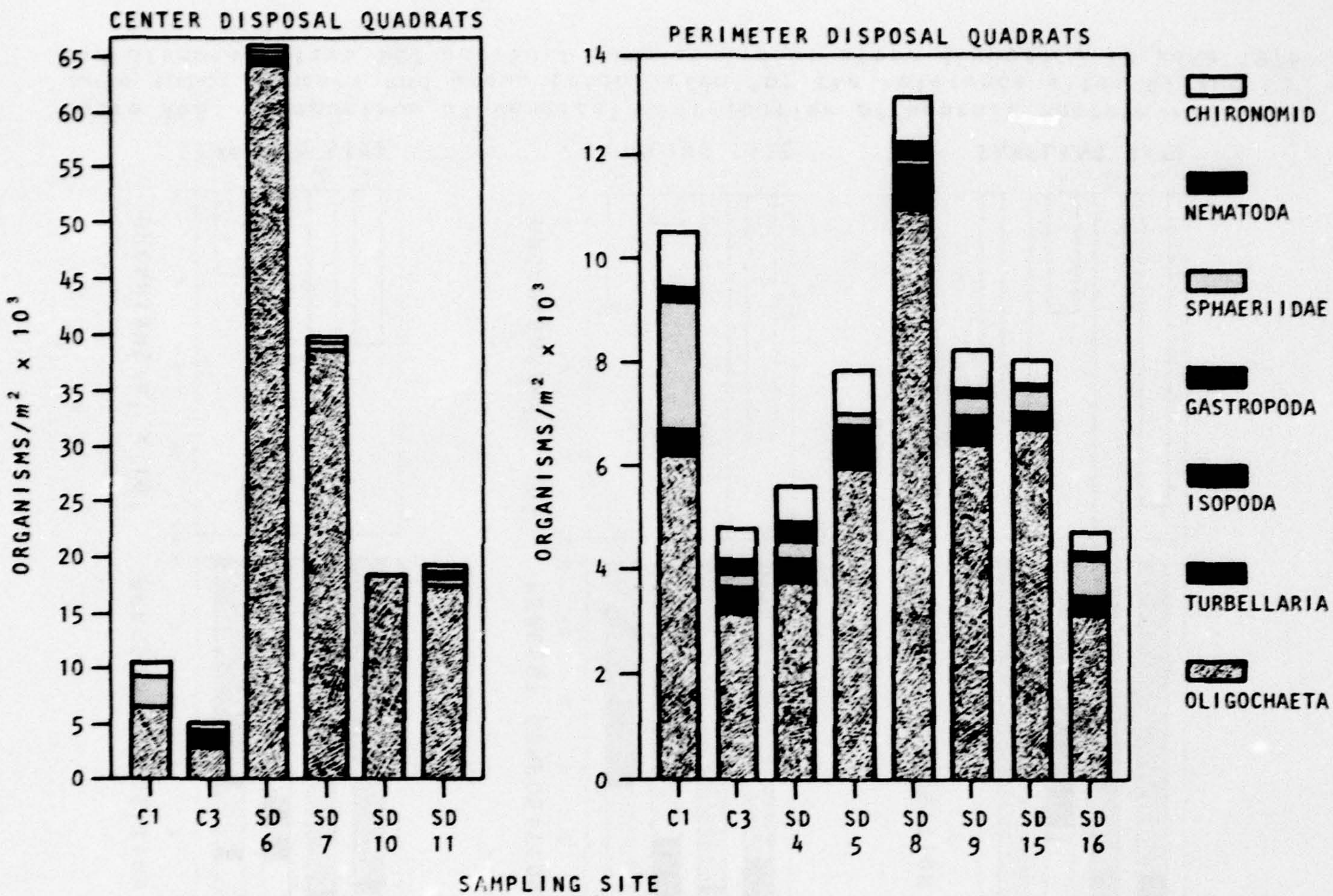

Figure A67. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites SD4-SD11, SD15, and SD16 sampled 5 days after disposal, 10 June 1976

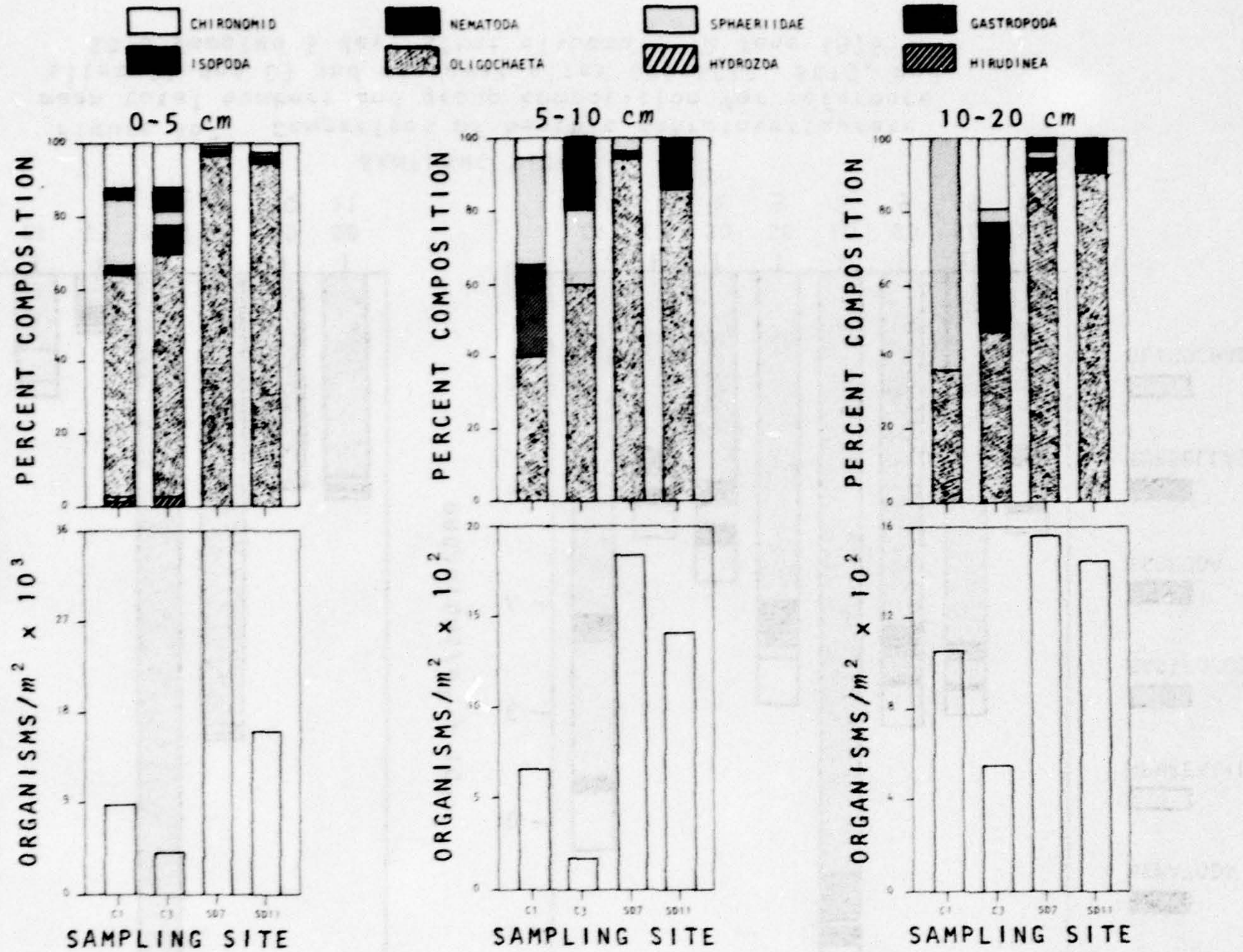

Figure A68. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for the reference sites C1 and C3 and disposal sites SD7 and SD11 sampled 5 days after disposal, 10 June 1976

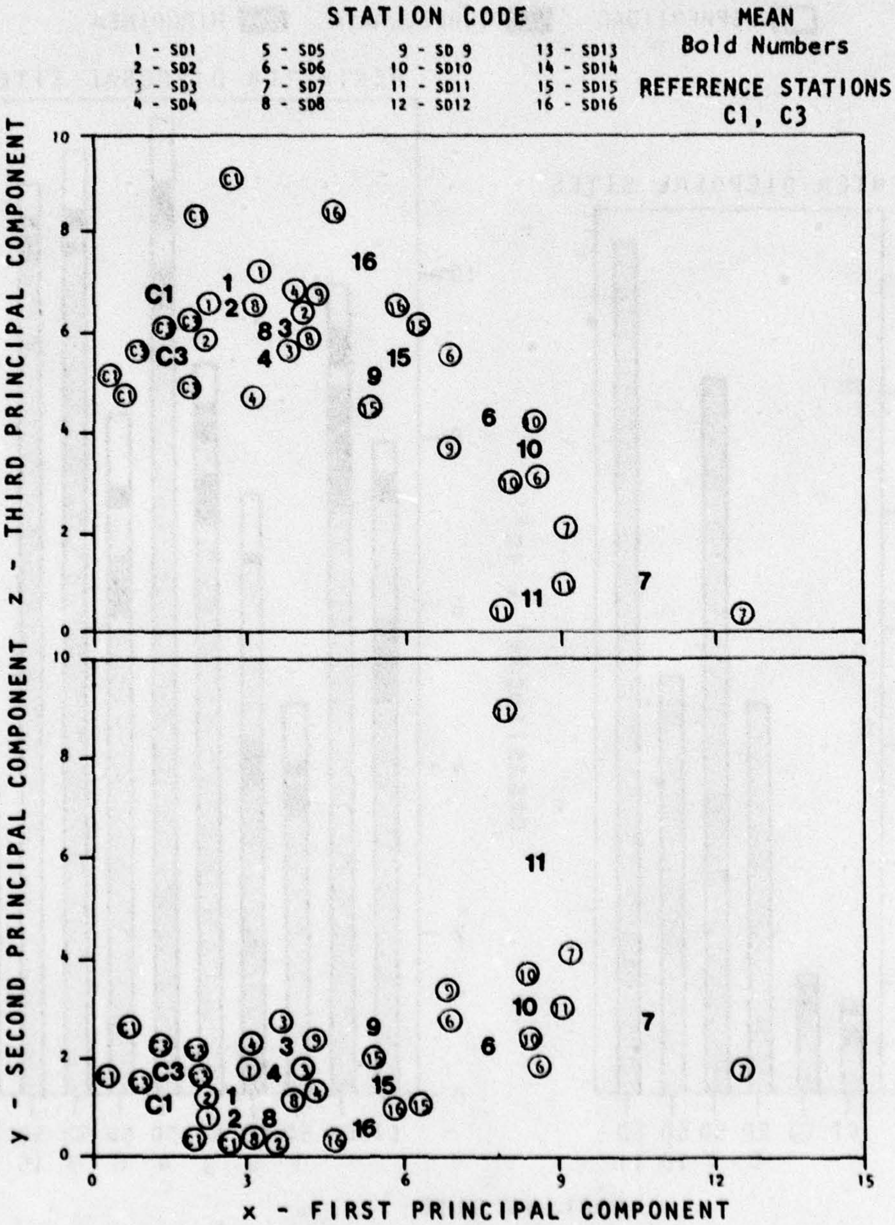

Figure A69. Community ordination (three principal components) of benthic macroinvertebrate logarithmic data for all sites sampled 30 days after disposal, 8 July 1976. Axis values are in ordination units while distance between sites reflects community similarity

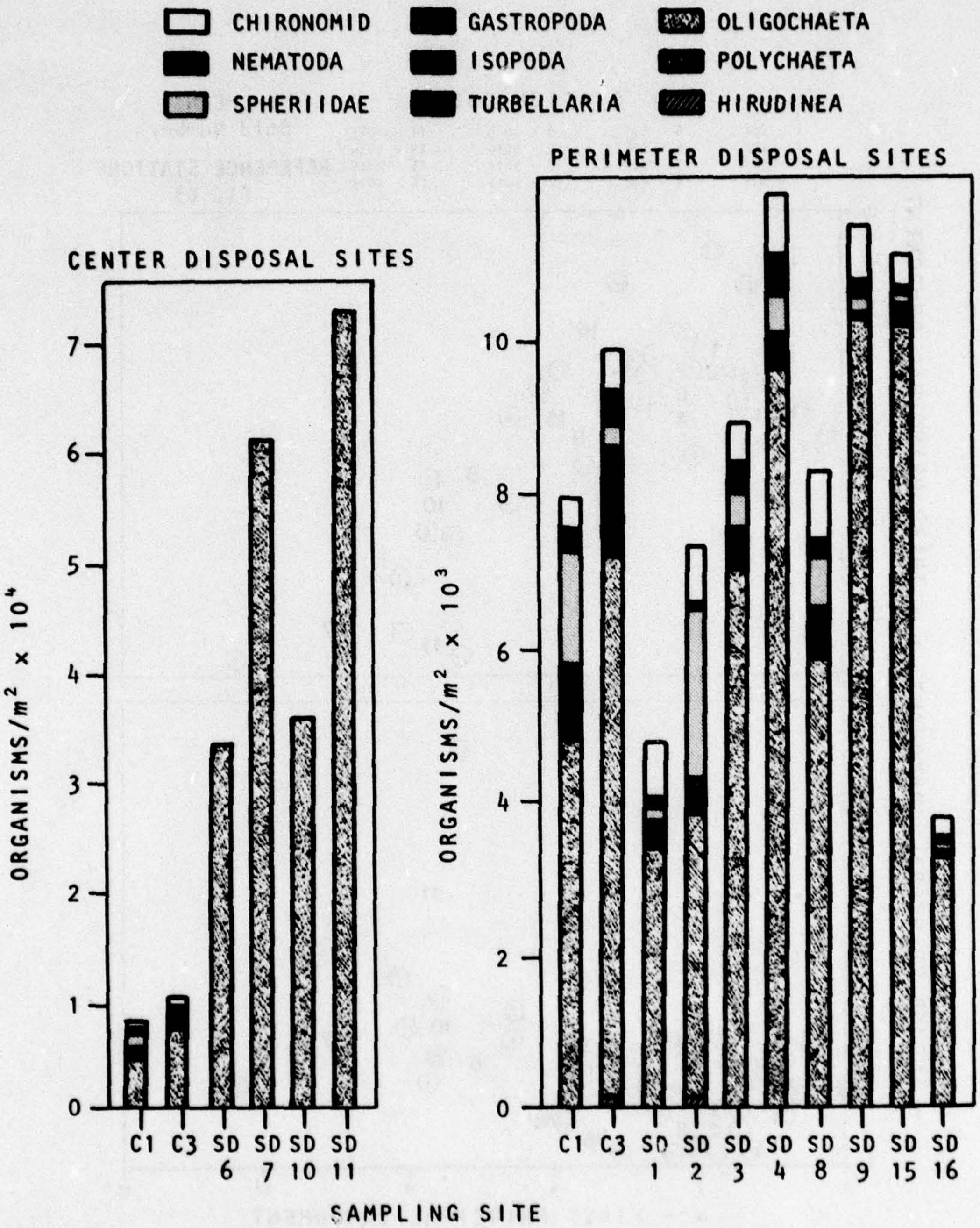

Figure A70. Comparison of benthic macroinvertebrate mean total numbers and group composition for reference sites C1 and C3 and disposal sites SD1-SD11, SD15, and SD16 sampled 30 days after disposal, 8 July 1976

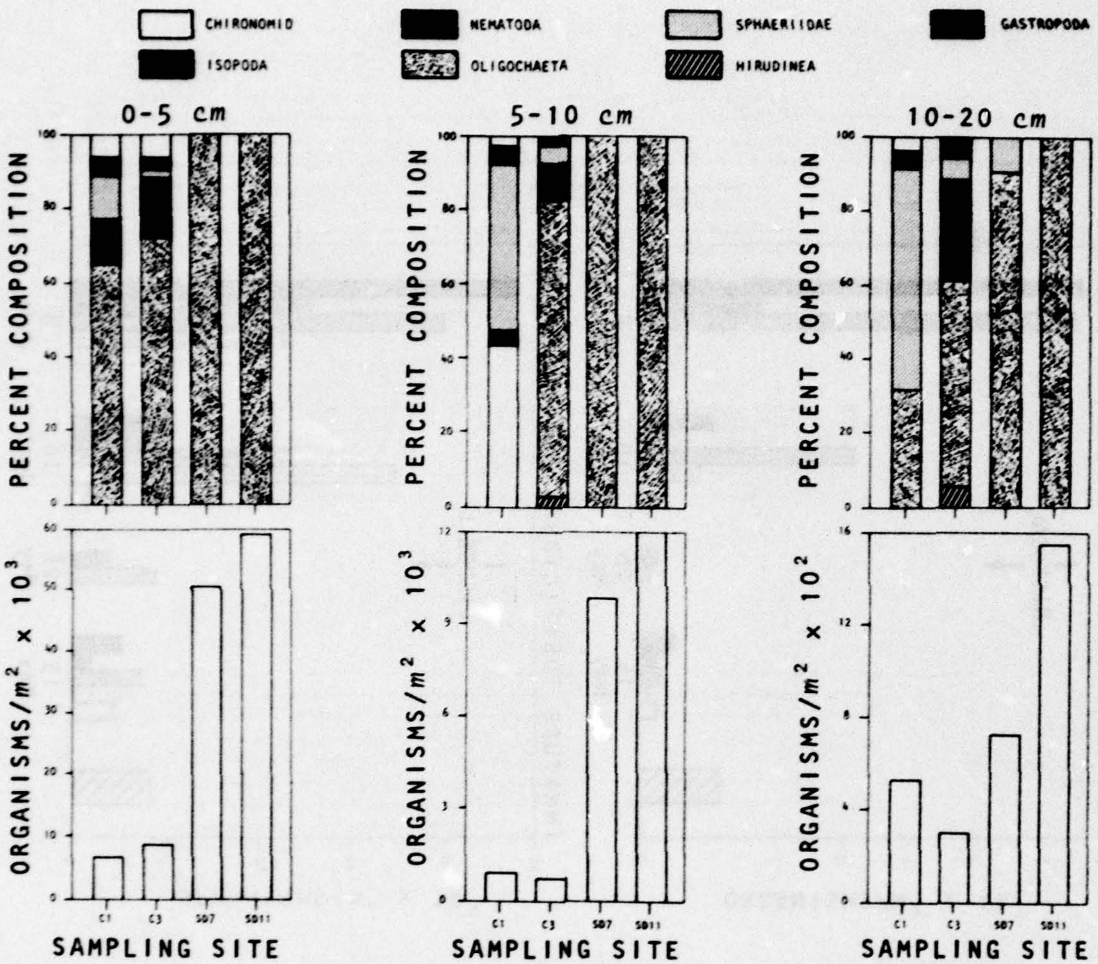

Figure A71. Comparison of vertical distribution of benthic macroinvertebrate mean total numbers and group composition for the reference sites C1 and C3 and disposal sites SD7 and SD11 sampled 30 days after disposal, 8 July 1976

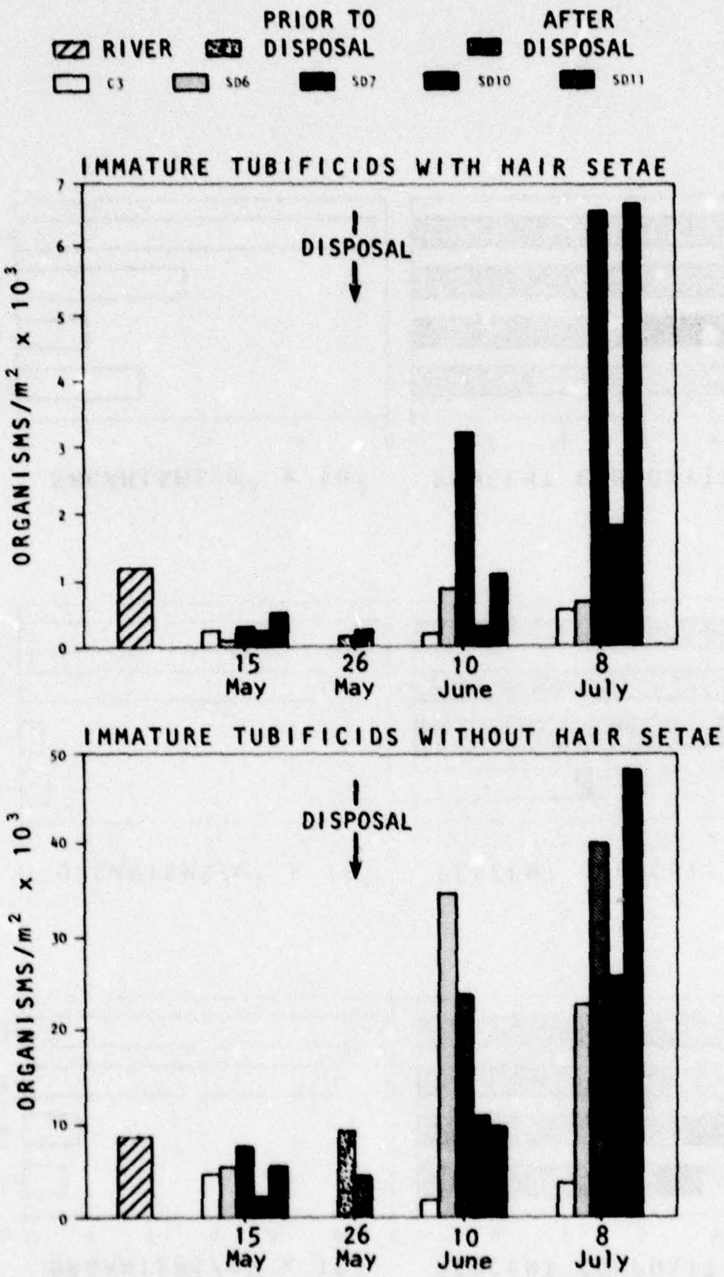

Figure A72. Mean number of immature tubificids with hair setae and without hair setae at the river sites before dredging and at the reference site C3 and center disposal sites SD6, SD7, SD10, and SD11 over the 1976 disposal study. Disposal occurred 24-26 May 1976. The 26 May bar graphs represent mean numbers of tubificids for samples taken prior to disposal and after disposal that day

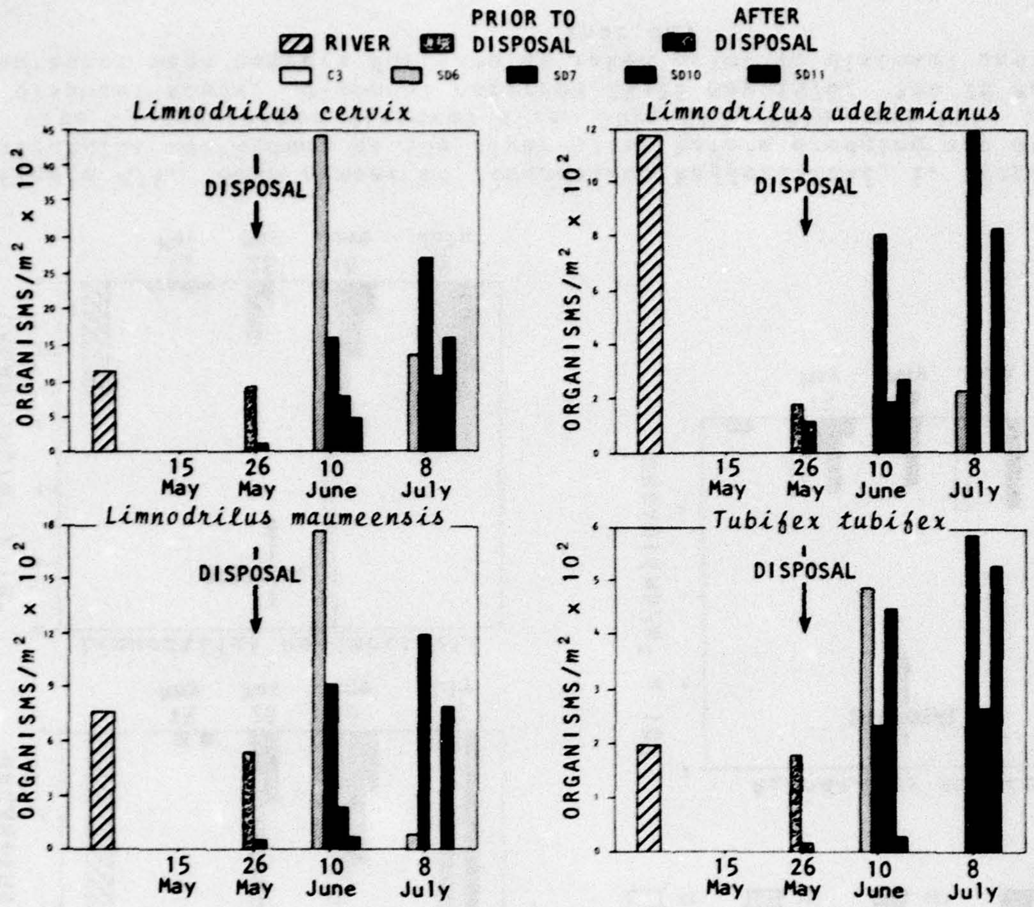

Figure A73. Mean number of *Limnodrilus cervix*, *L. maumeensis*, *L. udekemianus*, and *Tubifex tubifex* at the river sites before dredging and at reference site C3 and center disposal sites SD6, SD7, SD10, and SD11 over the 1976 disposal study. Disposal occurred 24-26 May 1976. The 26 May bar graphs represent mean numbers for samples taken prior to disposal and after disposal that day

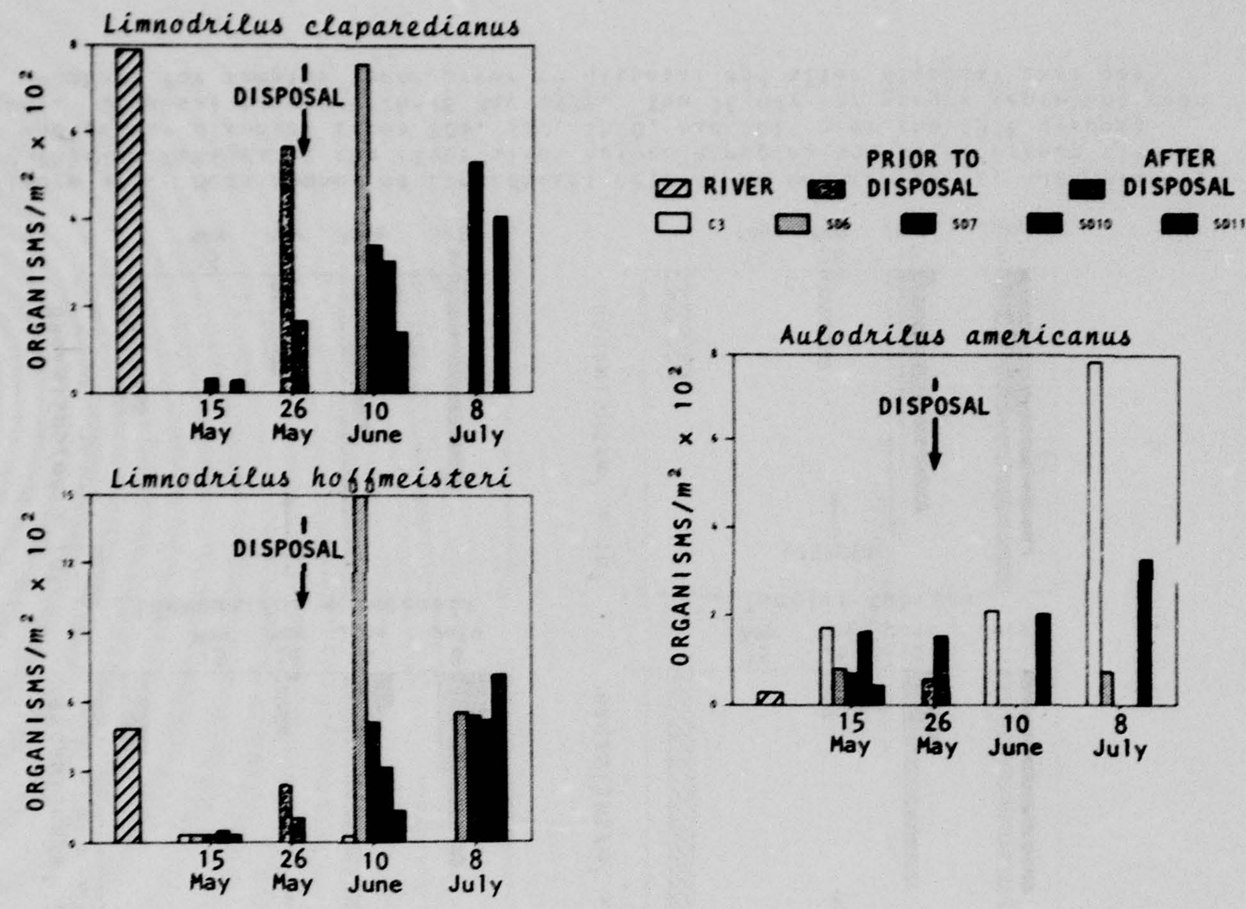

Figure A74. Mean number of *Limnodrilus hoffmeisteri*, *L. claparedianus*, and *Aulodrilus americanus* at the river sites before dredging and at the reference site C3 and center disposal sites SD6, SD7, SD10, and SD11 over the 1976 disposal study. Disposal occurred 24-26 May 1976. The 26 May bar graphs represent mean numbers for samples taken prior to disposal and after disposal that day

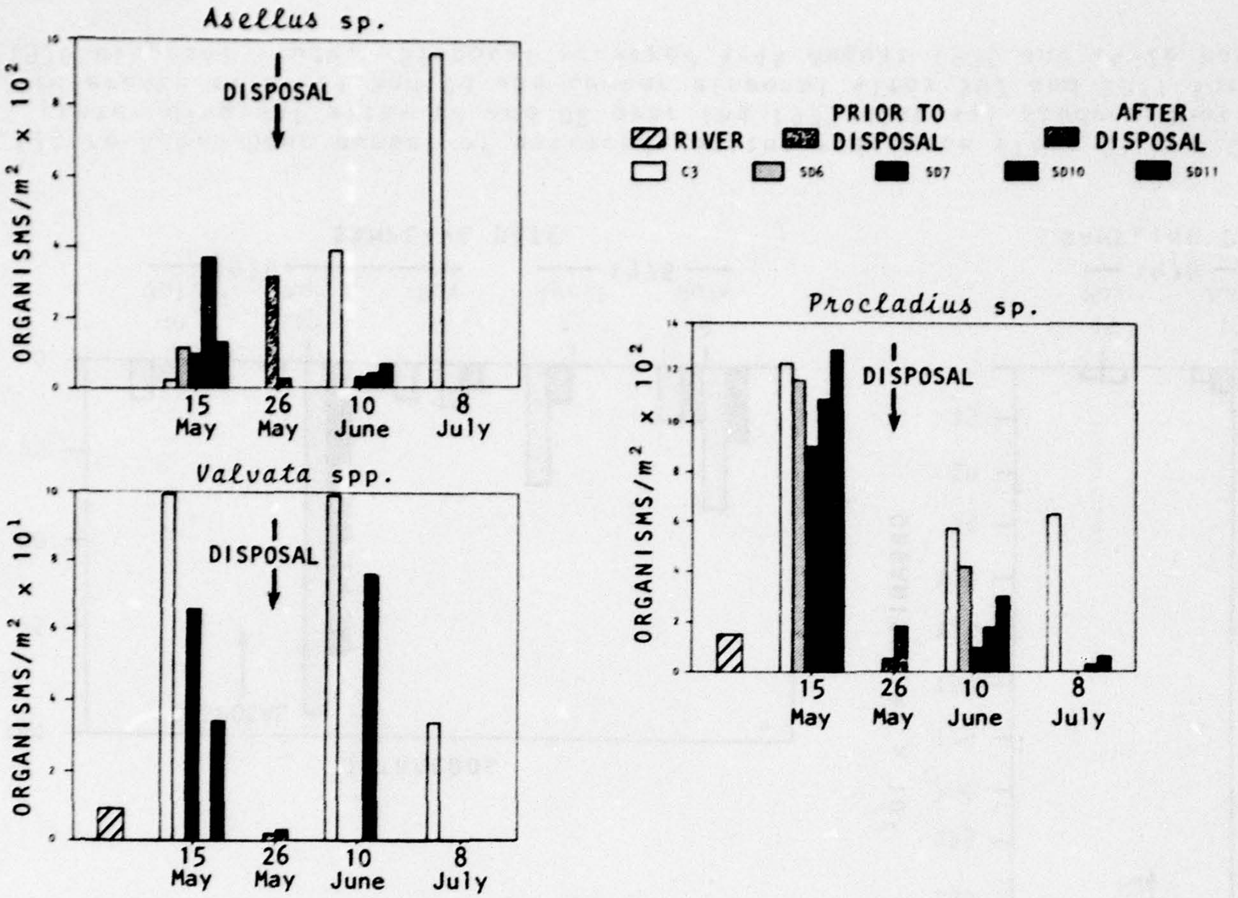

Figure A75. Mean number of *Asellus* sp., *Valvata* spp., and *Procladius* sp. at the river sites before dredging and at reference site C3 and center disposal sites SD6, SD7, SD10, and SD11 over the 1976 disposal study. Disposal occurred 24-26 May 1976. The 26 May bar graphs represent mean numbers for samples taken prior to disposal and after disposal that day

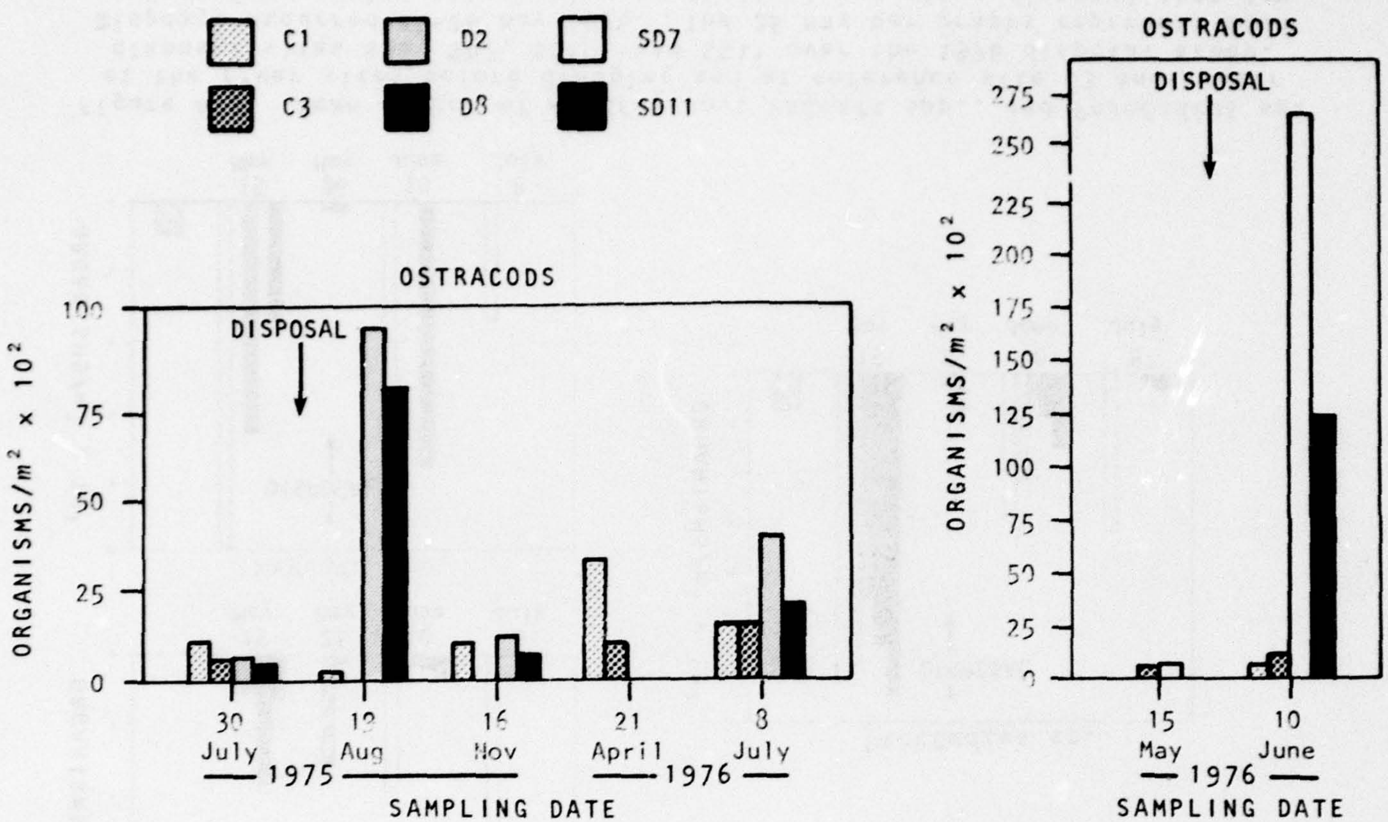

Figure A76. Mean number of ostracods at the reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study and at the reference sites C1 and C3 and center disposal sites SD7 and SD11 for the 1976 disposal study. Disposal occurred 4-14 August 1975 and 24-26 May 1976

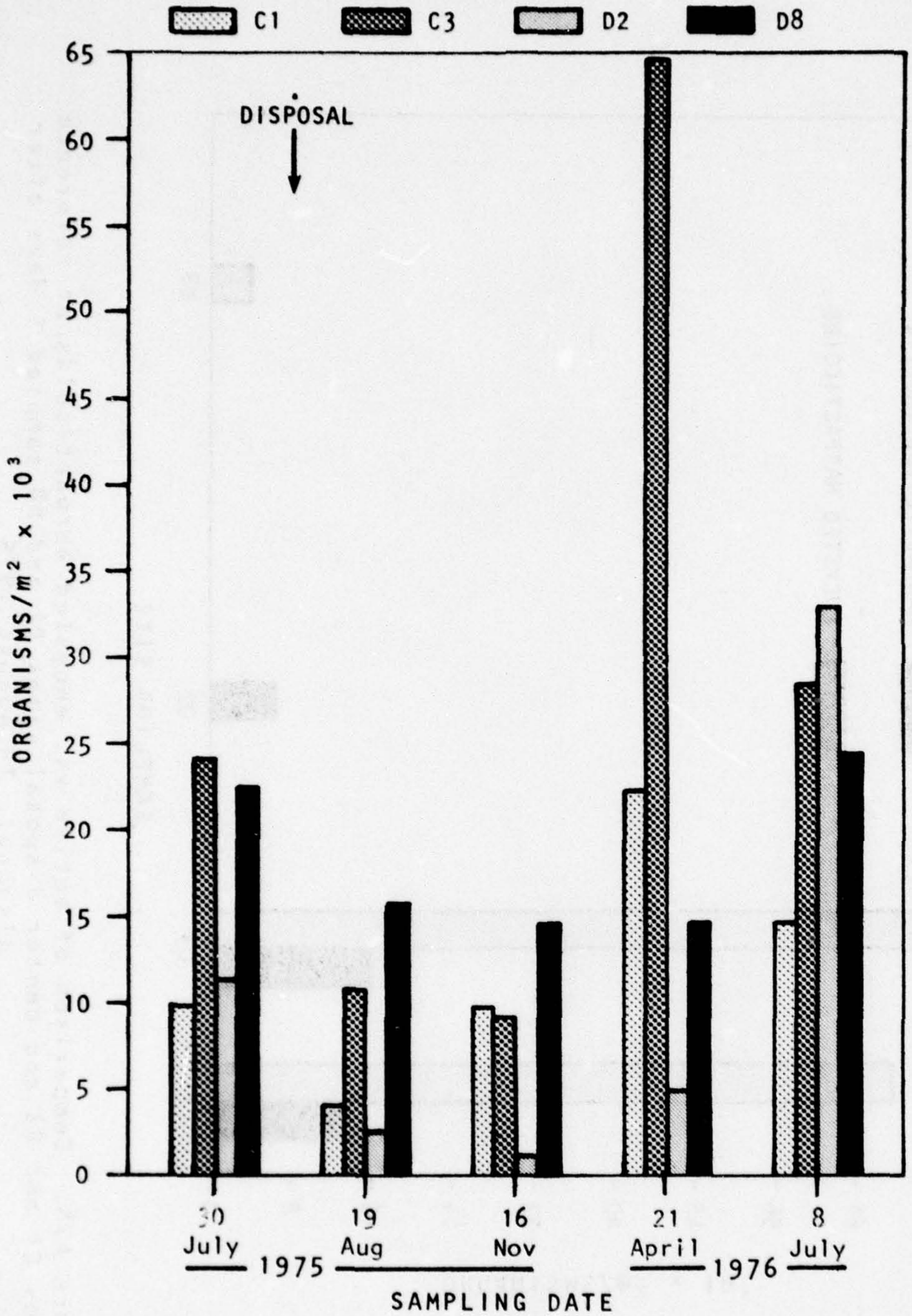

Figure A77. Mean number of harpacticoids at reference sites C1 and C3 and center disposal sites D2 and D8 over the 1975 disposal study. Disposal occurred 4-14 August 1975

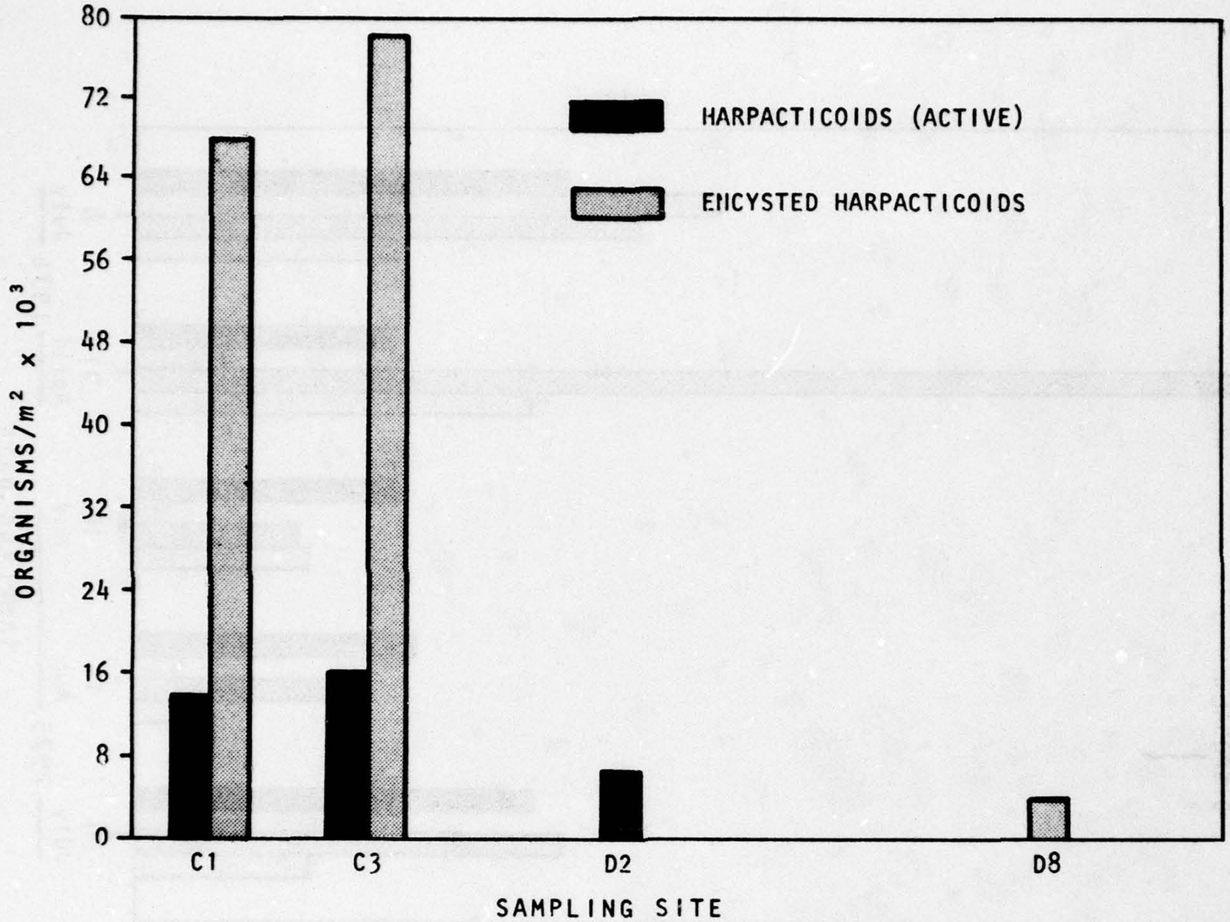

Figure A78. Comparison of active vs. encysted harpacticoids at reference sites C1 and C3 and center disposal sites D2 and D8 sampled 5 days after disposal, 19 August 1975

APPENDIX A1: TAXONOMIC KEYS AND DESCRIPTIONS USED IN THE IDENTIFICATION OF FLORA AND FAUNA ENCOUNTERED AT ASHTABULA, OHIO

PHYTOPLANKTON	
Bacillariophyceae	Patrich and Reimer (1966)
	Huber - Pestalozzi (1968)
Pyrrhophyta	Huber - Pestalozzi (1962)
	Fritsch (1965)
Chlorophyta	Prescott (1962)
Cyanophyta	Prescott (1962)
Others	Ahlstrom (1937)
	Tiffany and Britton (1952)
	Smith (1950)
	Taft and Taft (1971)
ZOOPLANKTON	
Calanoid copepods	Czaika and Robertson (1968)
Daphnia	Brooks (1957)
General Cladocerans and Copepods	Edmondson (1959)
BENTHOS	
Amphipoda	Holsinger (1972)
Isopoda	Williams (1972)
Gastropoda	Harman and Berg (1971)
Sphaeriididae	Herrington (1962)
	Burch (1972)
Hirudinea	Klemm (1972)

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APPENDIX A1 (CONTINUED)

BENTHOS (Continued)

Polychaeta	Foster (1972)
General	Pennak (1953)

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APPENDIX A2: ASHTABULA SPECIES LIST

PHYTOPLANKTON

CHLOROPHYTA

Chlamydomonas globosa

Gloeocystis sp.

Schroederia setigera

Tetraedron minimum

Sphaerocystis sp.

Ankistrodesmus falcatus

A. falcatus var. *acicularis*

A. falcatus var. *spirillisformis*

Golenkinia radiata

Chorella sp.

Closteriopsis longissima

Kirchneriella sp.

Oocystis sp.

Nephrocytium sp.

Lagerhemia ciliata

L. citriformis

L. quadriseta

Quadrigula sp.

Selenastrum sp.

S. gracile

Micractinium sp.

Dictyosphaerium pulchellum

(CONTINUED)

APPENDIX A2 (CONTINUED)

CHLOROPHYTA (Continued)

Actinastrum sp.

Coelastrum microporum

C. reticulatum

C. sphaericum

Scenedesmus sp.

S. quadricauda var. *quadrispina*

S. quadricauda var. *longispina*

S. bijuga

S. bijuga var. *flexuosus*

S. dimorphus

S. arcuatus

S. incrassatulus

Tetrastrum sp.

Crucigenia rectangularis

Pediastrum simplex

P. duplex

P. boryanum

P. tetras

Oedogonium sp.

Mougeotia sp.

Closterium parvulum

Cosmarium formulosa

(CONTINUED)

APPENDIX A2 (CONTINUED)

CHLOROPHYTA (Continued)

C. quadrum

C. punctulatum

C. depressum

Staurastrum gracile

PYRROPHYTA

Gymnodinium helveticum

Glenodinium sp.

Peridinium aciculiferum

Ceratium hirundinella

EUGLENOPHYTA

Euglena sp.

Phacus sp.

Trachelomonas sp.

CRYPTOPHYTA

Rhodomonas minuta

Cryptomonas erosa

C. marssonii

C. curvata

Katablepharis ovalis

(CONTINUED)

APPENDIX A2 (CONTINUED)

CHRYSOPHYCEAE

Dinobryon cylindricum

Mallomonas sp.

Chrysochromulina parva

BACILLARIOPHYCEAE

Coscinodiscus rothii

Diatoma elongatum

Skeletonema sp.

Melosira italica

M. islandica

Cyclotella sp.

Stephenodiscus tenuis

S. hantzschii

N. niagarae

S. binderanus

Asterionella formosa

Fragilaria capucina

F. crotenensis

Synedra sp.

Tabellaria fenestrata

Gyrosigma sp.

Navicula sp.

Nitzschia sp.

(CONTINUED)

APPENDIX A2 (CONTINUED)

CYANOPHYTA

Aphanothece sp.

A. nidulans

Chroococcus turgidus

C. dispersus var. *minor*

Coelospherium Naegelianum

Gomphosphaeria aponia

G. lacustris

Aphanocapsa sp.

Microcystis aeruginosa

Oscillatoria sp.

Anabaena sp.

A. circinalis

Aphanizomenon flos-aquae

OTHERS

Unknown micro-phytoflagellates

ZOOPLANKTON

CLADOCERA

Alona quadrangularis

*A. affinis**

Bosminids with mucro

Bosminids without mucro (*Eubosmina coregoni*)

Ceriodaphnia lacustris

(CONTINUED)

APPENDIX A2 (CONTINUED)

CLADOCERA (Continued)

Chydorus sphaericus

Daphnia ambigua

D. galeata mendotae

D. longiremis

D. parvula

D. retrocurva

Diaphanosoma leuchtenbergianum

Eurycercus lamellatus

Holopedium gibberum

Ilycryptus spinifer

*I. acutifrons**

*I. sordidus**

Leptodora kindtii

Leydigia quadrangularis

COPEPODA

Nauplii

Calanoid copepodids

Diaptomus ashlandi

D. minutus

D. oregonensis

D. sicilis

D. siciloides

(CONTINUED)

APPENDIX A2 (CONTINUED)

COPEPODA (Continued)

Eurytemora affinis

Cyclopoid copepodids

Cyclops sp.* (*Microcyclops*)

C. *bicuspidatus thomasi*

C. *vernalis*

C. *nanus**

*Eucyclops agilis**

Mesocyclops edax

Paracyclops sp.*

Tropocyclops prasinus mexicanus

Harpacticoid copepodids

Canthocamptus robertcokeri

BENTHIC ORGANISMS

HIRUDINEA

Helobdella sp.

H. *elongata*

H. *stagnalis*

NAIDIDAE

Amphichaeta sp.*

Arcteonais sp.

A. *lomondi*

Dero digitata

(CONTINUED)

APPENDIX A2 (CONTINUED)

NAIDIDAE (Continued)

Nais sp.

Ophidonais serpentina

Pristina osborni

Slavina appendiculata

Specaria sp.

S. josinae

Stylaria sp.

Vejdovskyella sp.*

TUBIFICIDAE

Unknown Tubificidae

Immature Tubificidae without hair setae

Immature Tubificidae with hair setae

Aulodrilus americanus

A. limnobius

A. pigueti

A. pluriseta

Ilyodrilus templetoni

Limnodrilus sp.

L. angustipenis

L. cervix

L. cervix (var.)

L. claparedianus

(CONTINUED)

APPENDIX A2 (CONTINUED)

TUBIFICIDAE (Continued)

L. hoffmeisteri

L. maumeensis

L. spiralis

L. udekemianus

Peloscolex ferox

P. freyi

P. multisetosus longidentus

P. multisetosus multisetosus

Potamothrix moldaviensis

P. vejdovskyi

Tubifex tubifex

POLYCHAETA

Manyunkia sp.

M. speciosa

AMPHIPODA

Gammarus fasciatus

ISOPODA

Asellus sp.

A. racovitzai racovitzai

OSTRACODA

HYDRACARINA

(CONTINUED)

APPENDIX A2 (CONTINUED)

HYDROZOA

Hydra sp.

GASTROPODA

Bithynia tentaculata

Amnicola sp.

A. *limosa*

A. *integra*

Valvata sp.

V. *lewisi*

V. *sincera*

V. *tricarinata*

V. *tricarinata basalis*

V. *tricarinata infracarinata*

V. *tricarinata perconfusa*

V. *tricarinata simplex*

V. *tricarinata tricarinata*

SPHAERIIDAE

Pisidium sp.

P. *idahoense*

Sphaerium sp.

S. *corneum*

S. *lacustre*

S. *securis*

(CONTINUED)

APPENDIX A2 (CONTINUED)

SPHAERIIDAE (Continued)

S. transversum

NEMATODA

Alaimus sp.

Aphanolaimus sp.*

Dorylaimus sp.

Laimydorus sp.

Tobrilus sp.*

Thornia sp.

Turbellaria

DIPTERA

CHIRONOMIDAE

Chironomini (Subfamily)

Chironomini (Tribe)

Chironomus sp.

Dicrotendipes sp.

Glyptotendipes sp.

Paracladopelma sp.*

Polypedilum sp.

Tanytarsini (Tribe)

Micropsectra sp.

Orthocladiinae (Subfamily)

Cardiocladius sp.

(CONTINUED)

APPENDIX A2 (CONCLUDED)

CHIRONOMIDAE (Continued)

Tanypodinae (Subfamily)

Procladius sp.

COLLEMBOLA

* Seen only in meiobenthic samples.

APPENDIX A': EFFECTS OF DREDGED MATERIAL DISPOSAL ON FISHES IN OFFSHORE AREAS

PART I: SITE DESCRIPTION

1. The physical description of the study area and historical remarks concerning dredging activities have been described in the preceding sections on benthos and plankton. These will not be repeated here.

2. The study area selected for fisheries investigations consisted of stations placed within an area bounded on the south by the shoreline of Lake Erie (including the lower 400 m of the Ashtabula River), extending 5 km east and west of the Ashtabula Harbor light and north a distance of approximately 6.5 km.

3. The area was characterized early in 1975 by a series of fathometer tracings at 47 sites, by gill net collections at stations which represented potential experimental or control sites, and by gill nets or seinings at sites near the shore where certain species were thought to be present. An evaluation of the gill net collections indicated that stations offshore were consistently similar in community structure and species relative abundance. Fathometer tracings supported this latter conclusion and extended the similarity in abundance to all stations > 3 km from shore. Nearshore sites (depths < 7.5 m), were strikingly dissimilar to the offshore stations and slightly dissimilar to each other, probably due to habitat variability.

4. Since offshore sites were consistently similar, the selection of experimental and control stations followed the decisions of the Great Lakes Laboratory. Stations D2, D8, and Reference were labeled F8, F17, and F18, respectively (Figure 1). An additional station, F28, was selected in order to more fully characterize and investigate the total areas' fish community. This was due largely to studies by White et al. (1975) which indicated faunal differences between nearshore and offshore areas near

Cleveland, Ohio.

5. Selection of the disposal site during the second year of study was again dictated by the Great Lakes Laboratory. This area, however, contained shale rubble and other habitat not found in the Control Area. As such, comparisons of feeding behavior before and after disposal could partially reflect the diversity of benthos in areas near the station (F7). It is believed, however, that the mobility of the nektonic organisms would have allowed feeding on the shale rubble during the first year of study as well.

6. During the Initial Survey it was found that the yellow perch was the dominant nektonic species at all offshore sites. Other species normally comprised less than 40% of the total collection at any station. Since yellow perch are demersal feeders during much of the year (Clady and Hutchinson 1976, Price 1963, White et al. 1974), and since they represented the most abundant sport and commercial species as well, it was decided to concentrate much of the effort studying the effect of disposal on this species. Less attention was given to other species collected.

PART II: METHODS

Sampling Procedures

7. The primary sampling technique used was the gill net. Because of catch selectivity, two types of gill nets were used: monofilament and braided nylon. The monofilament net, 500 ft (152.4 m) in length, 6 ft (1.83 m) deep, contained a series of 50-ft (15.2 m) panels of varying mesh sizes. These were of 1/2-inch (1.27 cm) intervals from 1-1/2 to 6-inch (3.81-15.24 cm) stretch mesh. The nylon net was 100 ft (30.48 m) in length and consisted of four 25-ft (7.7 m) panels, 1-1/2-, 2-, 3-, and 4-inch (3.81, 5.08, 7.62, and 10.16 cm, respectively) stretch mesh. These nets were attached to each other, making a complete net of 600 ft (182.88 m).

8. Nets were set at the bottom of the Lake and remained at a station for no less than 18 hr and normally for no longer than 24 hr. Occasionally weather conditions prohibited retrieval. These collections were considered invalid since catch per unit of effort normally decreases over extended periods of time. This is due to the increased amount of debris and dead fish in the net.

9. When nets were retrieved the fish were immediately removed and either frozen on dry ice or placed on ice. Species which decomposed easily, such as alewife, were injected with formalin to preserve the gut contents. Specimens were returned to the laboratory where they were either processed immediately or frozen for future processing.

10. Trawls utilized were of three types. An 18-ft (5.49 m) semi-balloon otter trawl was used for the bottom sampling as was a 5-ft (1.52 m) otter trawl. The latter was constructed of 1/2-inch (1.27 cm) mesh with a cod end of 1/8-inch (0.3 cm) treated ace netting. This trawl was used for the collection of young-of-the-year from bottom habitats. A mid-water trawl with adjustable doors was used for sampling at 4.5-10 m depths in offshore areas. This net was 15 ft (4.57 m) at the chain.

11. Trawls were towed on 300 ft (91.44 m) of line by a 36-ft (10.97 m) vessel equipped with stern capstan winches. Specimens collected in trawls

were preserved in 10% formalin and returned to the laboratory for processing.

12. Larval tow nets utilized in this study were 1 m in diameter. The nets were constructed of Nitex netting of 11.4 meshes per cm. Tows were made on 30 m of line behind an outboard motorboat. Tows were of 2 min's duration at a speed of 2.2-2.5 kph. The net was towed in a slightly circular path which enabled sampling to take place outside of the turbulence created by the boat and engine. Samples collected were preserved in 5% formalin and returned to the laboratory for examination.

13. Taxonomic identification of adult nekton was done in the field and in the laboratory by personnel familiar with the Great Lakes Basin fish fauna. Hybrids or species difficult to identify positively in the field were identified with the aid of Trautman (1957), Hubbs and Lagler (1964), and Scott and Crossman (1973). Raw counts for each gill net collection were corrected to reflect the number of individuals per 24 hr per 1000 ft (304.79 m) gill net.

14. Larval forms were examined under magnification using a 10-70 X binocular dissecting microscope. Collections also resulted in the ability to produce a series of growth stages for some species. This served to facilitate the taxonomic identification of sizes and stages not previously described in the literature.

15. Seining collections were made at two points in the Ashtabula River and in the shallows in the southwest corner of the Harbor. These collections were utilized only to document the presence of additional species within the study area. Seines used during these collections included a 4- by 5-ft (1.2- by 1.5-m) fry seine of 1/8-inch (0.3-cm) mesh, a 5- by 6-ft (1.5- by 1.2-m) common sense seine of 1/4-inch (0.6-cm) mesh, and a 20- by 6-ft (6.1- by 1.8-m) bag seine of 1/4-inch (0.6-cm) mesh. Fish collected were identified and enumerated in the field.

16. Fathometer tracings made during the course of this study were utilized only to determine general concentrations or abundances of fish; taxonomic identifications could not positively be made using this technique. It was possible to determine the identity of some of the

dominant species indicated on the tracings by combining trawls or gill nets with tracing techniques. Uncommon forms or species in moderate abundances could not be distinguished.

17. Tracings were made using a Ross Fine-line Fathometer, Model 400-A. The signalling transducer was supplied with the unit and had a 22° angle of signal. All tracings were made in a semicircular pattern for a period of either 2 or 5 min. Boat speed was maintained between 3.5-4 mph (2.2-2.5 kph). The unit utilized also was adjustable for sensitivity of echo receptibility. By increasing or decreasing the sensitivity range it was possible to distinguish between large and small nektonic organisms. Over the course of the study sensitivity runs combined with mid-water and bottom trawls allowed documentation of the major species present. Tracings were made at all stations during the 1975-76 period. These were taken at least once per month during monitoring periods, although usually many more were made. Tracings were made more frequently during disposal operations and for special studies.

18. Adult fish collected were processed in the laboratory either fresh or after thawing. Weight and length (standard and total) were recorded for each specimen. Scales were removed from the left side of each fish at a point above the lateral line and just below the dorsal fin insertion. Scales were placed in serially numbered envelopes. The specimen was then opened and the sex was determined. Sex, length, weight, date of collection, and collection sites were recorded on data sheets and on the scale envelopes. The stomach was then removed and placed in a vial of 5% formalin. The vial was numbered with the same number assigned to the scale sample. The mouth and oesophagus were examined and any food material present was added to the stomach vial. Stomachs which were ruptured were recorded as such on the laboratory data sheets.

19. Fish scales were impressed on plastic (2.54 by 7.62 cm, 0.01 cm) slides using an Ann Arbor Scale Roller Press. Impressions were read to age determinations according to techniques described in standard literature sources. Ages were determined by two different readers and the results compared.

20. Those readings which were in conflict (< 5%) were reread by a

third individual. All age determinations were corrected to reflect months of age rather than the normal technique of years plus. This was done by comparing known spawning month, date of collection, and number of annuli present. Ictalurids were not aged because of the time and difficulty involved in sectioning pectoral spines. Spines were collected, however, and have been stored for future reference.

21. The contents of each stomach were removed and examined under a binocular dissecting microscope. Organisms present were removed and placed in clean solutions of 5% formalin. Detritus present was then examined under a compound microscope for the presence of algae, oligochaete setae, etc. All organisms present were enumerated and identified to the lowest taxon possible.

22. Fish species present were identified occasionally by external morphological characters. More frequently, however, osteological characters present in remaining skeletal elements were utilized. These included pharyngeal teeth, vertebral morphology or count, gill rake structure, otolith structure, and others. In most cases identification was possible to genus, and since many genera in the study area are represented by only one species, identification was often to this level.

23. Benthic organisms normally were identified to genus and enumerated by direct count. Classification of these organisms was done using keys and literature identical to that described in the benthic section of this report.

24. Zooplankton present in stomach contents were treated as a standard zooplankton collection. In cases where the number of organisms was < 100, direct enumeration was done using a binocular dissecting microscope. In cases where larger quantities of organisms were present, the collection was serially diluted and subsampled. Depending upon the initial size of the stomach collection, replicate subsamples (two to five) were counted. Numbers of each taxa were then corrected to the original sample size. Classification of zooplankton normally was accomplished to the generic level using keys described in previous sections of the biology report.

25. Phytoplankton subsamples were examined as a standard technique for species such as alewife, gizzardshad, carp, and suckers. Subsamples

of detrital material were processed in a manner similar to that used for a phytoplankton collection. Subsamples were examined with an inverted microscope in the same manner as described in the phytoplankton section of the biology report.

26. Detrital material (mud, sand, sticks, etc.) was identified and placed in separate vials for volumetric determination.

27. Volumetric determination of stomach contents was accomplished by calculation of volume of organisms upon intake rather than in the partially digested state. In the past, volumetric analysis of fish stomach contents has been done largely by displacement techniques. These involve determination of actual material in various states of digestion. The main problem with this method is rate of digestion of various organisms. Since fish, crayfish, or snails digest less rapidly than chironomids or isopods, the inherent error could yield incorrect conclusions. Often it is stated that this is academic since ingestion time is a factor; thus volumes will "average out" with a sufficient sample size. Should feeding be constant over a 24-hr period, this would probably be true; however, those species in the Ashtabula area might feed at certain intervals and not constantly.

28. This study utilized a method of analysis which involves the calculation of volume based on entire organisms. Specimens of fish and benthic food items were obtained from the Astabula study area by various techniques. These were preserved in 10% formalin and returned to the laboratory. After sorting organisms into various taxa, they were separated into size classes at 1-mm intervals. Sufficient numbers of each size class utilized were obtained until at least 1.5 mℓ of specimens were available.

29. Volumes of organisms of each size class were then determined by volumetric displacement techniques. The volume of each sample was calculated to 0.001 mℓ. Groups of individuals of each size class were utilized until at least 10 measurements (each with a different number of individuals) were obtained. Mean values for a single organism of each size class were determined.

30. The data for the different size classes of each taxon were then processed and a formula for the length-volume curve was obtained. This formula was then used to provide a table of volume for all length classes

(including those for which insufficient quantities of organisms could be obtained). In all cases, correlations between calculated and observed volumes were > 0.950, and in some cases a correlation of 0.997 was obtained. Such tables were created for benthic organisms and for fish remains (backbone length, head length, etc.).

31. Planktonic organisms such as harpacticoids, daphnia, and others were also evaluated using the intake volume techniques. In this case, the system of Rhodes and McComish (1975) was used in which volumes were calculated by comparison with the volume of a most similar geometric shape. The calculations of Rhodes and McComish were obtained and utilized for these volume determinations.

32. Phytoplankton was a food item which contributed little to the total volumetric intake of most species. No volumetric determinations were made on these algal cells. These organisms were identified and enumerated but were considered as having only trace value in volumetric studies. Detritus collected from stomach samples was centrifuged or determined by displacement, depending on the type of material involved.

Fish Egg Bioassays

33. Fish egg containers used in the bioassay tests were constructed of Plexiglas. Frames were made and covered with 18 mesh per inch Nitex netting. Three boxes were placed on each Plexiglas base to serve as replicates. The base was attached to an anchor and buoy. Rainbow trout eye/stage eggs were obtained from a commercial supplier. The eggs were acclimated to the surface Lake water at the Disposal Site by successive water changes over a period of 2 hr. After acclimation was completed, each container received 50 eggs and was placed in the Lake. Racks of three boxes each were lowered at a rate of 1 m per 5 min to minimize the effect of temperature and pressure changes. Egg boxes remained at each site during the remainder of the disposal period. The location of experimental egg containers is shown in Figure 2. Racks were placed as controls at Station F18, and to determine the effect of depth, a rack was placed at Station F28 (Figure 3).

34. Egg racks were lifted and checked for silt content, development of

eggs, and hatching success. The racks were lifted at a rate of 1 m per min. to maximize pressure acclimation of developing individuals. Successive lifts or racks at Stations F18 and F28 indicated a minimal effect of mortality due to pressure or temperature change.

35. Ordination analysis was performed on total monthly nekton collections to aid in the determination of the effect of disposal on the offshore fish fauna. It was believed that changes might be observed due to avoidance or attraction of species of communities. Ordinations were used to summarize relative changes between sites and between predisposal and postdisposal periods at individual sites.

36. A similarity/dissimilarity index was used (Simpson 1949) as modified by Overton (1976) to reflect community relationships and/or change within communities. These methods were also used to evaluate the feeding behaviors. In this case, the food intake of all individuals was combined and treated in a manner similar to a benthic collection, as described in previous sections of this report.

37. All calculations were compared by discriminate analysis techniques and computed based on a $P \leq 0.05$ level. Routine calculations (means, species diversity, etc.) were done on a Burroughs 5500 Computer utilizing packaged routines available at John Carroll University.

Sampling Design

38. Once the Reference and Experimental stations had been established, a long-term monitoring program was conducted. This program was specifically designed to establish effects resulting from dredged material disposal. Aspects investigated in 1975 included community structure, attraction, or avoidance by specific species, and feeding behavior. Continued fathometric surveys during June and July of 1975 indicated similar fish abundance at all offshore stations. Gill net collections demonstrated that the yellow perch continued to be the dominant species throughout the period.

39. Disposal operations began on 4 August 1975. Immediately prior to the disposal event, a series of fathometric tracings were made at

stations indicated in Figure 4. These tracings were of 2-min duration and were made at the Disposal Site and at four points, each approximately 300 m from the center of the Disposal Area. These four points were located north, south, east, and west of the center of the Disposal Area. The final fathometer tracing was completed < 5 min prior to the actual disposal event.

40. A gill net was also set immediately prior to the disposal event. The net was set in the southeast quadrant and remained in place for a period of 2 hr (Figure 4).

41. Postdisposal monitoring consisted of a continuation of gill net collections and fathometric studies. Gill nets were placed directly over the disposal piles at both sites and were set at three sites per day. Normally, nets were set to include the Control Site during every collection day. Monitoring continued through November, at which time ice and poor weather conditions forced a suspension of collections.

42. During the 1976 season, the 1975 monitoring program was continued. At the same time, collections for predisposal evaluations were conducted at Station F7 (NDS). In addition to the gill net and fathometric techniques, trawls, and larval tow nets were implemented at all sites. It was found that trawling the bottom was extremely difficult due to the shale and rock rubble present and only a limited amount of data were collected. Larval tows at the surface were conducted at all stations at regular intervals.

43. Studies during the disposal period were conducted with fathometric techniques to determine the response of fish to the disposal plume. Tracings were made during the disposal operation and for a period of 15 min after disposal. These tracings were made by travelling back and forth across the Disposal Site as the dredge pulled away from the area. The plume was visible on the fathometer tracings and the runs were terminated after the path of the vessel had left the area of the plume. Sensitivity on the fathometric tracings was sufficient to distinguish fish at least as small as 5 cm (White 1977).

PART III: RESULTS

Species Composition and Abundance

44. No recent, specific studies are extant which describe the fish fauna of the Ashtabula area in terms of distribution, abundance, or temporal fluctuations. No studies were available which describe the presence or distribution of fish larvae in the area, and no studies were available which described the feeding behavior of any species in the Ashtabula area. Therefore, considerable baseline information was gathered concerning all aspects of the fishery, both onshore and at the Experimental Sites. Sampling for general distribution patterns and abundance commenced in July of 1975 and continued through August of 1976. Sampling was suspended during the winter months due to ice and poor weather conditions. A complete listing of fish species present in the Ashtabula area is presented as Table 1.

45. An investigation into the distribution of these species during the study period revealed that a significant difference existed between communities in the extreme nearshore areas and those areas with depths of > 7.5 m. Table 2 demonstrates that many species in the Ashtabula area are not normally present in the Disposal Area, and thus were not available for study of effects. Those species present in the Experimental Areas were also present, sometimes in greater numbers, in areas of shallower waters. Although community structure was different, these results were consistent with the results of similar studies near Cleveland, Ohio (White et al. 1975).

46. During the summer predisposal studies, a steady decline in the total fish abundance was documented in the Experimental Area. These populations (primarily the dominant species, yellow perch) continued to decline steadily until early August (Figure 5) when the lowest level was recorded. During the 1-14 August period, it was not uncommon to catch no yellow perch in a 600-ft (182.88-m) gill net set for 18-24 hr. Fathometer tracings made during this predisposal monitoring period supported the lack of yellow perch in the study area. Figures 6-8 are indicative of the extremely low population present.

47. Mid-water species also demonstrated slight declines during the late summer, although smelt, alewife, and gizzardshad were present in small

numbers. Large schools of small fishes, mainly young-of-the-year smelt, were present at depths of 15-40 ft (4.5-12.2 m). These results were not entirely unexpected since trends indentical to these have been observed in Cleveland waters and elsewhere (White 1974; White et al. 1975).

48. Fish populations began to increase in September and reached a peak in November when sampling was discontinued due to weather conditions and shore ice formation. Studies by Caroots (1976) indicate that this increase continues throughout the winter, principally due to increases in adult gizzardshad. Smelt also increase during the winter period (White 1974). Yellow perch near Cleveland demonstrate offshore declines during January and February, with subsequent increases to the highest level of the year in April-early May. Such an annual abundance cycle is probably true also of the Ashtabula area.

49. Samples were first taken in 1976 in March, shortly after the disappearance of Lake ice. These samples indicated that offshore populations of perch, smelt, trout-perch, and gizzardshad were all very low. Offshore populations of yellow perch increased steadily through April and May, while dramatic increases were observed near shore in May. Spawning occurred in May and extended into the early portion of June. Nearshore and offshore populations of nearly all species, including yellow perch, remained relatively constant through the May-June period. In July the decline in yellow perch numbers that occurred in nearshore areas was as striking as the May increase. However, increases continued in offshore areas, which probably was the result of offshore movement of nearshore fish. Species other than yellow perch maintained their high numbers throughout the May-September period.

50. By late August of 1976, as in 1975, offshore yellow perch populations had declined to very low levels. It was not uncommon during this period to capture no fish of any species in a 24-36 hr gill net collecting period. Nearshore yellow perch populations had again begun to increase, as was the case in 1975. The fluctuation of the yellow perch population that occurs in the offshore study area was shown to consist of two peaks -- one in the June-July period and a lesser one in late September-October. The lowest numbers of yellow perch were recorded at no perch per 24 hr per 1000 ft of gill net. This was documented on 5-9 August 1975 and 20-28 August 1976 (Figures 9-12).

51. Other species in offshore areas also declined in numbers as summer progressed. Smelt reached a peak abundance in mid-May when spawning mortality drastically reduced the population of adults. Yearlings of smelt, however, were abundant at mid-water depths throughout much of the summer. Alewife, young gizzardshad, and trout-perch exhibited declines in offshore areas similar to those demonstrated by the yellow perch. By August these species had become extremely rare in offshore areas.

52. Throughout the study period the yellow perch was clearly the dominant species present in the bottom waters of offshore areas. Most collections contained 80-100% yellow perch, and rarely was a collection made where yellow perch comprised $<$ 60% of the total catch. Perch abundances thus became the overriding factor in community structure. In fact, during some periods, perch comprised the entire community of larger demersal nektonic forms. Species diversity was poor in the bottom waters of all offshore areas, again due to the influence of the yellow perch population. Shannon-Weaver diversity indices normally ranged from 1.10 to 0.01 or less. To utilize community structure in this instance would have been a valuable tool for predicting impact only if large numbers of additional species or numbers of a few species had colonized the Disposal Area. Since this did not occur, and since yellow perch populations remained similar at all sites, the impact of disposal must be considered to have been due to a lack of species available for colonization, however, and disposal in areas where a diverse community structure is present might result in different impacts.

53. Short-term changes in fish populations due to disposal were undetected. While during 1975 few fish were available to observe, the 1976 disposal event occurred during a period of moderately high fish populations. At all sites, however, a decline in yellow perch populations occurred during the late May-early June period. It appears that fish were moving onshore during this brief period. Thus, declines evident during the postdisposal period at Station F7 (Figure 9) were also evident at Stations F8 and F18 (Figures 10-11). It was concluded that this was a general movement of offshore fish and not due to activities associated with the disposal operation.

54. In late June a reverse trend was observed at all offshore stations

as populations of yellow perch climbed to the July peak. Again, the increase was general in the offshore area and could not be attributed to any attraction of the fish to the Disposal Site.

55. Fathometric surveys during all phases of the study demonstrated results similar to those observed in gill net collections. Predisposal tracings during 1975 indicated declines in offshore bottom fish fauna until early in August, when only an occasional demersal fish was indicated on each tracing (Figures 6-8). Mid-water fauna were observed only on the fathometer tracings since no mid-water trawls were made as a part of the 1975 program. These small schools of mid-water nektonic organisms were assumed to be composed primarily of smelt, alewife, and gizzardshad. All offshore stations exhibited extremely similar fish populations on the tracings.

56. The response of fish to the disposal operation in 1975 was investigated with fathometric techniques. Predisposal period tracings taken at five Disposal Area stations and the Control Site were similar in that only occasional demersal nektonic organisms were observed. Tracings taken immediately after disposal (at Stations F8 and F17) indicated that those few bottom-dwelling individuals present at the Disposal Site had left the immediate area. Tracings at the four sites 300 m from the disposal remained unchanged from those taken immediately prior to disposal (Figures 13-17).

57. The small schools of mid-water nektonic organisms were also absent from the Disposal Site but, as with the demersal species, remained at similar levels of abundance at all other sites. Tracings from all disposal events demonstrated identical results. Thus, it was assumed that the response of fishes in the immediate Disposal Area was to retreat from the area and that the response of fishes > 300 m distant was negligible.

58. Consideration was given to the possibility that the disappearance of fishes from the Disposal Site was due to either being buried or killed by the disposal event. In order to examine this possibility, gill nets were set approximately 200 m from the site of the disposal. The nets were placed perpendicular to a line between the net and the Disposal Site buoy. Nets were retrieved within 5 min after disposal and were examined for the presence of fish and directionality of movement into the net.

59. In all cases, only a few (three to six) fish were captured during the 5-10 min period. However, since 24-hr net collections yielded zero to three fish during this period of the year, such a catch represents a considerable increase in catch per unit of effort. All fish collected in nets during these experiments were moving away from the Disposal Site. Thus, it was tentatively concluded that the limited number of demersal individuals present migrated away from the disposal event rather than having been buried by it. The limited number of fish present in the area, however, makes such a conclusion very tenuous and further documentation would be necessary prior to presenting positive results.

60. During the period from 10 min to 30 min after the disposal event, additional tracings were made at five Disposal Area stations. These tracings indicated that both pelagic and demersal nekton began to return to the Disposal Area within 10 min, and after 30 min had repopulated the area to levels similar to that immediately prior to the disposal event. After 10 hr the fish populations at all five stations appeared to be identical (Figures 18-22).

61. Fathometric surveys were continued throughout September, October, and November. In all cases tracings were similar at all offshore sites, again supporting gill net data. Population of both demersal and pelagic fauna increased throughout late September and October. No concentrations of fish were noted on disposal piles during any postdisposal samples; thus it was concluded that the Disposal Area had neither a negative nor a positive influence on fish distribution.

62. In March of 1977 fathometric surveys were once again initiated. The results were similar to those of the postdisposal period in 1976. No avoidance or concentrations were observed at the two Disposal Stations F8 and F17. Surveys also served to document predisposal conditions at five stations: F7, F8, F17, F18, and F28. As before, all offshore stations exhibited similar patterns of distribution and abundance on the tracings.

63. Because of the response documented during 1975, it was decided to investigate more intensely response to the disposal event and its associated plume. It was apparent in 1975 that response was minimal and

consisted primarily of the retreat of individuals for only short distances.

64. In order to study the immediate response of fish species to the dredged material as it fell and created a disturbance, a series of tracings were run on transects across the Disposal Site during disposal and then repeatedly for 5-10 min after disposal. Sensitivity on the fathometer was adjusted until the disposal plume was barely indicated, in which case the position of both fish and the plume could be recorded (Figure 23). The accuracy of this method was documented by collecting water samples from a Van Dorn bottle when the bottle appeared in the plume as indicated by the tracing.

65. During the disposal event it was documented that the response of fish to both the disposal event and the plume was minimal. Tracings clearly show mid-water species immediately adjacent to plume material (Figure 24). In certain instances, "curls" in plume configurations created what appeared to be nonturbulent portions within the plume. These areas often contained fish (Figure 25). Thus, it was considered a possibility that mid-water species were present within the plume material but hidden on tracings because of the intense echo patterns of the plume. This response of mid-water nekton was documented during every disposal event.

66. The response of demersal species was slightly different, primarily due to the difference in the physical disturbance in near-bottom areas. Plume material, and perhaps a shock wave, seemed to hug the bottom and roll away from the Disposal Site. The combined effect of the shock wave, large volumes of material hitting the Lake bottom, and the moving plume appeared to frighten fish from the area. This is probably the reason for the disappearance of fish from the Disposal Site in 1976 and the capture of these individuals in the gill nets. Unfortunately, due to the placement of large numbers of sediment traps in the area, gill nets could not be employed during the 1977 disposal event.

67. Some of the demersal individuals appeared to react to the plume edge in a manner similar to that of the pelagic species. Figures 26-29 demonstrate the response of both demersal and mid-water species to the

disposal event. As may be seen, repopulation of the Disposal Site begins within 10-15 min after the disposal event occurs, and within a very short time (usually 30 min to 1 hr) the area is similar to the conditions prior to disposal.

68. Fathometric surveys during the later portions of the disposal period produced interesting results, especially during an accidental disposal event that occurred at Station F8. During this single disposal, on 27 May 1976, the presence of smelt was documented within the disposal plume using a mid-water trawl pulled at a depth of 9 m.

69. Disposal at this site occurred at 1735 hr in the presence of the research vessel, Welch. The mid-water trawl was employed and was pulled through the plume across the site of disposal (Figure 30). The completed trawl run, 10 min in duration, yielded 231 smelt. Immediately, a second trawl run was begun (1745 hr) which was made in the same direction but approximately 300 m north of the site of disposal. The results of this 10 min trawl were 225 smelt and 1 emerald shiner.

70. Since it appeared that populations inside and outside of the plume area were similar, trawl runs were made during another disposal event at Station F7 (Figure 31). Shorter trawls were made (5-min duration) but with similar results. Two trawls made through the plume contained 56 and 74 smelt, respectively, while a trawl made outside of the area contained 41 smelt.

71. Mechanical problems with winches forced the discontinuance of mid-water trawling during the remainder of the disposal period. It was documented, however, that fish were present within the disposal plume, apparently in concentrations very similar to those of nearby areas. Further examination of this lack of avoidance is certainly justified for future studies, especially since uptake of certain toxins or heavy metals could be occurring during this short interval.

72. Fathometric surveys taken during the June-August postdisposal period indicated results similar to those observed in 1976. No avoidance or attraction was noted at the Disposal Site and all offshore stations appeared comparable during each sample period.

Egg Mortality Studies

73. In order to determine the possible effect of disposal on egg survival, an experiment was conducted using a bioassay technique. Eyed eggs of rainbow trout placed at depths from 25-60 ft (7.6-18.3 m) were utilized to determine mortality rate at various distances from the Disposal Site. Eggs were placed at the stations indicated in Figure 2 on 28 May 1976. These eggs were lifted and examined at Station F28 on 4 June 1976 for a preliminary examination. The 3 egg boxes, each containing 25 eggs, were free of silt, indicating that the apparatus was not trapping fine particulates. Boxes were colonized by gammarids, snails, and a few isopods. <u>Hydra</u> sp. were extremely abundant on the boxes and the rack. Of the total of 75 eggs, 8 appeared undeveloped; the remainder were either hatched or in some stage of development. The rack and eggs were returned to the site.

74. On 8 June the eggs from Station F28 were again lifted and examined. It was discovered that all eggs had either hatched or were about to hatch -- indicating that all of the eggs were alive on 4 June. Figure 32 indicates the results of one of the boxes containing 25 eggs lifted on 8 June 1977. As shown in the figure, no silt was present in the box after the 10-day period and most of the yolk sac fry were in excellent condition.

75. After examing the eggs in the shallower waters at Station F28, the egg boxes placed at the control station were lifted. Of the 75 eggs placed at this site, only 8 were dead. All others were in some state of development, including 22 which had hatched. Ten of the yolk sac fry were dead but were not decomposed. It is possible that they died from pressure changes during lifting operations. From these data it was determined that the eggs would develop and hatch at offshore depths similar to those at the Disposal Site, and that the egg boxes neither trapped silts nor harmed the eggs in any unforeseen manner. Egg mortality was 0.0% at Station F28 and 10.7% at the Reference Station F18.

76. During the period of experimentation, at least two disposal

events took place at Station F8. This was in error, and while it negated the possibility of determining mortality of eggs due to the 10-month old disposal material, it did allow some determination of the effect of a small amount of disposal material on the eggs. The egg boxes were lifted on 8 June, and slight amounts of silt were present in each box (< 2 mm). The boxes were colonized by gammarids, Bithinia sp., isopods, and small numbers of planarians. The Bithinia sp. and planaria were not seen on the F28 or F18 boxes; it was probable that they were transported with the dredged material. The boxes had been placed approximately 50 m from the marker buoy, but the position of the dredge during disposal is unknown. It was probably more than 100 m from the eggs during disposal.

77. The 75 eggs present in the boxes suffered a higher mortality rate than those from the Control Site. Twenty-eight eggs were dead (47.4%) while the remainder were either hatched or still in some stage of development. Fifteen yolk sac fry were alive; ten were recently dead, perhaps from lifting the boxes, and four had been dead for some time prior to lifting the boxes. It was possible that the four-fold increase in egg mortality was due to the disposal of small amounts of dredged material 50-100 m from the eggs.

78. Egg boxes placed 50, 100, and 150 m from the Disposal Site (F7) buoy all suffered a mortality rate of 100%. All boxes contained silts ranging from 12-0.5 cm. Figure 33 indicates the condition of the 100-m egg box location. Table 3 presents the mortality rates and silt accumulation at each site. It was demonstrated that disposal produced a 100% mortality rate to demersal eggs for a distance of at least 250 m from the site of disposal. Mortality rates from Station F8 indicate that the effect would be apparent but at diminishing mortalities in areas where the disposal material was far less concentrated. It is probable that the 100% mortality rate extends only as far as siltation from the disposal event, probably not much further than 400 m, although further experimentation would have to be carried out to determine the exact extent of the area impacted. Egg boxes at the disposal locations were colonized by large numbers of planaria, hydra, gammarids, isopods, and Bithinia sp.

Feeding Behavior

79. During the course of study more than 6000 fish stomachs were collected and processed. These included more than 20 species of fishes, but consisted principally of stomachs from yellow perch, rainbow smelt, alewife, eastern gizzardshad , and trout-perch. A listing of food items taken collectively from all fish stomachs appears as Table 4. Numbers of stomachs examined for each taxa appear in Table 5.

80. It was interesting to note that while the oligochaeta were the most dominant benthic food source, they were not utilized by the Ashtabula area fish fauna. These organisms appeared in fewer than 10 stomachs during the course of the experimentation, and then only a single or a few organisms were present. It appears that these are eaten only occasionally or by accident. As such, they constitute a nonfood source, and any changes in abundance or species composition in this group would have no effect on food resources for the fish fauna.

81. The offshore adult fish population was principally composed of seven species: yellow perch, trout-perch, freshwater drum, rainbow smelt, emerald shiner, alewife, and eastern gizzardshad (Table 2). Emerald shiners were only rarely found far from surface waters, while rainbow smelt and alewife primarily inhabited midwater habitats. Eastern gizzardshad were uncommon during summer months, thus were poorly represented during disposal activities. Yellow perch, trout-perch, and freshwater drum were the principal species inhabiting bottom areas, thus, were most likely to be affected by disposal activities. Of these, yellow perch were clearly dominant, comprising > 90% of the combined catch.

82. Since alewife, eastern gizzardshad, and rainbow smelt fed primarily on algae, phytoplankton, and/or zooplankton (Tables 6-8), they were not impacted by the effects of disposal. This supports the conclusions of the plankton section of this report. Therefore, these species were not given further consideration in the results or discussion.

83. Yellow perch, trout-perch, and freshwater drum were all found to feed on benthic invertebrates as well as on fish. Trout-perch and freshwater drum, however, were collected in too few numbers to be utilized for any

evaluation of feeding behavior changes, especially in view of the short-term effects of disposal. Feeding behavior of these species is presented in Tables 9-10. Yellow perch remained, therefore, as the single species that was both benthic feeding and abundant enough for feeding behavior evaluation. Also, since it was the most important sport and commercial fish in the area, most of the experimentation and monitoring was directed in favor of this species.

84. Yellow perch stomachs were collected principally from five stations: F7, F8, F17, F18, and F28. During the course of study, a total of 3983 yellow perch stomachs were collected from the above sites. Of these stomachs, 1776 contained food items, 1323 were empty, and 884 were ruptured. Food and detrital items present were classified among various categories (Table 4) and evaluated by both numbers present and volume of intake.

85. From these data it was possible to determine monthly or seasonal changes in feeding behavior. Table 11 demonstrates monthly changes in feeding among yellow perch collected at offshore stations (F7, F8, F17, and F18) insofar as major food items are concerned. These feeding behavior fluctuations demonstrate clearly that yellow perch rely almost entirely on three food items: isopods, chironomids, and small fish (smelt and young alewife). Changes in the populations of these food species (and, thus, their availability) seem to have played the most important role in the feeding behavior of the yellow perch. In March, young fish from the previous year are unavailable to offshore perch since most of them have grown to be too large or are in nearshore areas. Chironomids, comprising only 0.75% of the total volume, were small (5-11 mm) and may have been too small to be an attractive food item. Thus, isopods (95.15%) and leeches (4.10%) formed the bulk of the diet.

86. April feeding behavior demonstrated that some additional chironomidae were being eaten and that some fish (principally emerald and spottail shiners) were being utilized. However, perch populations continued to rely heavily on the leeches and isopods (73.05%). Isopods found in stomachs during this period ranged in size from 9-15 mm, thus

providing an organism with considerably more volume per unit than the chironomids. Amphipods were also utilized to some extent during April (8.09%).

87. During the May through June period, feeding behavior is altered by the pupation of the offshore Chironomus sp. population and their emergence. In 1975 this pupation and emergence apparently occurred in late May and early June, thus was not observed to greatly affect the percentage of isopods in stomachs. In 1976, however, the pupation-emergence occurred in mid and late June and greatly altered the percentages. During this period of about two weeks, pupal Chironomid stages are free in the water column and constitute a large, easily captured food source for the yellow perch. Isopods are largely ignored, even though they are available, and during this brief period, Chironomus sp. constituted nearly 100% of the stomach contents.

88. By altering the 1975 and 1976 May, June, and July stomach content data, it is possible to place both years in synchrony so that the effect of Chironomus sp. pupae is easily recognized. A comparison of isopods and chironomus indicates that a ratio of Asellus sp. to Chironomidae of 10:1 occurs in pre-pupation collections in 1976. In early pupation periods of both 1975 and 1976, the ratio became approximately 3:1, and during pupation-emergence in both years, the ratio was approximately 1:10.

89. Post-emergence periods (July) indicated drastic reductions in both isopods and chironomids. This was due largely to the combination of three factors working simultaneously. First, the chironomidae were largely unavailable -- most had pupated and emerged and the newly hatched larvae were too small to constitute a food source. Second, isopod populations had peaked (Great Lakes Laboratory 1977) and were also unavailable in the area. Third, a major supply of an alternate food source was becoming available, young alewife and smelt. These latter species were spawned in May-early June and had become of sufficient size (30-60 mm) and were sufficiently abundant to be easier prey for offshore yellow perch. In both years, a shift from benthic food items occurred in early July, and in both 1975 (71.76%) and 1976 (73.02%), these two fish species comprised the major food source.

90. August continued a similar trend with alewife and smelt forming the bulk of the diet. As fall approached, a reverse trend began. Isopod populations had increased (and individual isopod size) and were more heavily utilized until November when isopods had climbed from the August low of .02% to 68.86%. Concurrent with this change in isopod populations was a movement of young smelt and alewife to the nearshore areas. This made them less available for offshore yellow perch.

91. Since no samples were collected in winter, it is not possible to discuss the feeding behavior between December and February. Figure 34 summarizes the adjusted annual feeding behavior of yellow perch, based on chironomid emergence on 1 June of any given year. As may be seen, the utilization of such items as amphipods and leeches remains fairly constant during most months, while snails form important portions of the diet only during late September.

92. Once annual feeding cycles were established, comparisons were made between the offshore areas and nearshore sites. This was in order to determine if fish were moving from offshore to onshore to feed on a diurnal basis. Figure 35 indicates food volume differences for onshore and offshore yellow perch stomachs. It becomes immediately obvious that the major offshore food items, isopods and chironomids, are poorly represented in onshore stomachs.

93. Daily comparisons indicate similar results for all collections, and if Asellus sp. is used as a "tag" organism, one may easily justify the concept of "localized feeding" behavior in yellow perch. No onshore movement can be documented as Asellus sp. does not appear in > 0.5% of stomachs onshore at any time of the year. This conclusion is strengthened by the fact that Asellus sp. does not appear to be present in nearshore areas (Alldridge et al. 1977, Great Lakes Laboratory 1977).

94. Other supportive evidence includes the presence of crayfish, tricopterans, mayflies, and other organisms found only in nearshore stomachs. Since these were not taken in predisposal collections at offshore stations, it seems conclusive that daily onshore-offshore feeding migrations are minimal among the Ashtabula yellow perch population.

95. Since it was established that certain schools of yellow perch fed locally, it was possible to obtain a list of organisms associated with stomach samples obtained in each area (onshore vs. offshore). These "tag" organisms were utilized to determine the possibility of feeding on dredge-transported materials in offshore areas. Table 12 presents a listing of organisms considered to be usable as indicators of such an occurrence.

96. In addition to these organisms, certain types of detrital material were transported to the Disposal Site during the operation. While such detrital items as leaf litter, sticks, or sand could have been present in the study area before disposal, the occurrence of certain detritus items after disposal would indicate that feeding was taking place on the disposal piles. Items utilized in this determination included pieces of asphalt, slag and gravel from River samples, pieces of coal, concrete chips, plastic fragments, grease or bunker oil, tar, wood chips, and plant detritus such as leaves, sticks, or seeds.

97. Stomach samples from the four offshore stations demonstrated conclusively that feeding was occurring on the disposal piles. Predisposal and postdisposal samples are compared for detrital materials in Table 13. It becomes clear that postdisposal feeding occurred on the disposed material. Disposal-associated detritus at Station F8 is probably due to the disposal of an unknown quantity of dredged material on this site. (Two loads were observed being disposed.) However, Stations F17 and F18 produced no detrital materials which are definitively associated with disposal (slag, asphalt, bunker oil, etc.) while such items were common at the Disposal Site.

98. The feeding on the disposal materials was further supported by the presence of foreign species of "tag" organisms at Stations F7 and F8. Hydracarina, Ephemeroptera, Tricoptera, and Bithinia sp. were common in postdisposal stomachs at F7 in 1976, while a few tricopterans and a specimen of water mite were taken at Station F8. Station F18 produced only one foreign organism during this period in 1976, a tricopteran, and none in the 1975 postdisposal period. Table 14 illustrates foreign organisms present for the predisposal and postdisposal periods at each station. It is clear that feeding occurs on the disposal pile and that organisms and detritus form a portion of the diet in the Disposal Area.

99. It was also clear that these organisms and detritus formed a very small portion of the total food intake. Volumetric intake for all food items at Stations F7 and F18 are presented in Table 15 for the post-disposal period from 1 June-31 July. Non-food items from disposal and foreign organisms provided < 1% of the total intake at Station F7 and < 0.01% at Station F18. It is possible, however, that the chironomids and amphipods, which formed a major food source, were also transported to the Disposal Site. This was a strong possibility since chironomids increased in importance during June, while isopods declined as a food item. The Great Lakes Laboratory's report on benthic changes indicated that isopod populations were eliminated from the immediate disposal area and that chironomids were a large portion of benthic foreign organisms transported to the site (other than oligochaetes).

100. A comparison of isopod and chironomid intake by yellow perch was made between the Reference Station (F18) and the Disposal Station F7. By making monthly comparisons of abundance of the two taxa, it was shown that the increase in chironomids throughout the April-June period had occurred at both sites, and that this was also true for the decline in isopods. Figure 36 illustrates the comparison of Stations F7 and F18. The numerical abundance (expressed as a percentage of total benthic food intake) of both taxa is nearly identical for all months. Since these shifts in food items had occurred at both sites, it was concluded that feeding behavior changes as related to the isopods and chironomids were part of the natural annual feeding cycle and were not related to the disposal operation. Figures 37 and 38 represent similar calculations for the entire 1976 study period (1 March-1 August). Stations F7, F8, and F18 demonstrate similar predisposal and postdisposal feeding patterns, including the shift from isopods to chironomids during the postdisposal period (Tables 16-18).

101. In summary, it can be stated that the yellow perch population fed in local areas offshore and did not migrate nearshore daily to feed. They were documented as feeding on disposal piles and in the immediate vicinity. Feeding behavior showed no evidence of change as a result of

the disposal operation, except that an insignificant portion of transported detritus and foreign organisms was eaten in areas near the disposal operation. It was further shown that in all offshore areas, isopods, chironomids, and small fish form the bulk of the diet. Since these organisms are extremely abundant in all offshore areas, it is unlikely that disposal operations could seriously reduce the food supply. It was shown further that food items utilized in nearshore areas were quite different. Since these items (crayfish, gammarids, snails, etc.) might be more susceptible to the effects of disposal, it is important to consider the area of disposal as being in "offshore" habitats. While this is rather easy to accomplish in the central basin, the western basin presents habitats similar to the nearshore zone of Ashtabula. Areas should be selected that are characterized by a muddy bottom at depths > 8 m wherever possible. Table 19 is a list of stomach contents of yellow perch.

102. Using Simpson similarity-dissimilarity indices, a plot was made of the two-dimensional Euclidian distance relationships of feeding behavior at Stations F7, F8, F17, F18, and F28. In the first instance, all stomach collections were divided into predisposal and postdisposal periods for 1977. These 10 sets of stomach contents were compared. Figure 39 indicates the relationships of the 2 periods. It is apparent that the relationship of stations to each other during the two periods is more similar than is the relationship of each station to itself between the two periods. In both cases, F7, F8, and F18 show distinct similarity, while F28 (nearshore) is equally dissimilar in both instances. Station F17 tends to fall somewhere between the offshore set and F28, probably because it is the shallowest of the Experimental Sites and because fish consumption at this site tended to be higher in other offshore areas. This latter characteristic tended to shift F17 toward the F28 pattern where fish were a dominant food item.

103. The shift of Station F17 toward a nearshore feeding pattern is even more apparent in the 1976 predisposal plot of the five stations (Figure 40). Postdisposal comparisons, however, primarily during the period when fish were available to all offshore stations, indicate similarity of all offshore sites. The nearshore site differed primarily in the species of fish utilized (gizzardshad, shiners, and alewife) while

the offshore sites fed principally on rainbow smelt. No separation of the Disposal Station F7 from the other offshore stations could be determined during the postdisposal period (Figure 41).

PART IV: DISCUSSION

104. As discussed in the section pertaining to planktonic organisms, effects on pelagic fish species appear to be minimal. Adults and young of these species were unaffected by the disposal events. They were found to enter plume material with regularity and were collected in similar numbers at all offshore stations during each sampling period.

105. The floating eggs of the emerald shiner and pelagic fish larvae appeared to be unaffected as well. However, since elutriate studies were not conducted, it is not possible to discuss effects of plume materials on these young stages. A potential impact such as that described in elutriate studies on phytoplankton could occur with these larvae.

106. Bottom-dwelling fish species responded negatively to the actual disposal event by migrating from the immediate area of disturbance. The area was quickly repopulated, usually within 15-30 min, and within 1 hr after disposal, the fish populations appeared similar to all other offshore locations. It is probable that this rapid repopulation of the Disposal Area was due to the general random movement of the fish fauna, especially since no attraction or concentration of fish at the Disposal Site was noted. Since fish are present on the Disposal Site so soon after disposal, it is also possible that toxic materials leached from the sediment could be accumulated by this segment of the fish population.

107. Studies on the species composition of all sites in offshore areas indicated that during the course of the entire study, all sites were similar. No significant changes could be ascertained either in diversity or abundance of individual species. It was felt that movement past the disposal piles or in the general area supported the belief that the disposal piles were not inhibitive to the local fish fauna. Probably no disruptions in general migratory patterns would occur as a result of dredged material disposal.

108. Because of the importance of isopods and chironomids in the diet of the yellow perch, the impact of disposal on these organisms becomes more critical. While documentation of a reduction of chironomids and an elimination of isopods was established in the benthic study,

suggestions were also made that these organisms migrated from the area rather than having been buried and killed. If the disposal area was very small, the normal foraging behavior of the yellow perch would enable it to find isopod sources in nearby areas, but if disposal occurred over larger areas (with the same effect), a food source might become seriously depleted.

109. Within 90 days, chironomid populations were again present in disposal areas and these could have served as an alternate food source for yellow perch. However, during the post-emergence period for chironomids in late July and August, these are naturally unavailable. Snails, which are not normally a principal food item, could be utilized, but results indicate that these were affected in the same manner as the isopods. With disposal of similar quantitites over a larger area, yellow perch would be forced to turn to an alternate source of food, namely other fish species.

110. Studies of seasonal feeding behavior suggest that yellow perch shift food items based on availability. Food intake is dominated by isopods in spring with an increasing amount of chironomids through mid-May. During chironomid emergences in July, the isopods and snails become less important and chironomid pupae form the bulk of the diet. Fish and snails become more important in offshore feeding areas after July. Fish and chironomids become increasingly important as winter approaches.

111. Considering the above, the widespread disposal of dredged material in late summer or fall would have little effect on feeding behavior. Small fish show little response to disposal, thus, would still be available as a food source. Chironomids, the major spring-summer food source, would be expected to be available by then, as would isopods. Similar disposal of material in late spring could have the effect of removing the benthic food source at a time when fry or young-of-the-year fish are unavailable. This would force benthic-feeding fish populations to move temporarily to other areas to feed, resulting in a secondary avoidance of disposal areas. Yearly spring disposal in the same area could conceivably eliminate certain food sources in the immediate area. This was not seen as a critical problem for the perch population since

most of the offshore areas appear to contain an abundance of both isopods and chironomids.

112. Inasmuch as disposal operations seemed to have little effect on long-term yellow perch feeding behavior, it was considered possible that these fish were captured on the Disposal Site but had fed elsewhere. Stomach analyses indicate that this was not the case. Stomachs from Disposal Areas contained detrital items not present at the Reference Site. Some of these items were undoubtedly from the disposal of dredged material. These include bunker oil, slag, and asphalt. Others such as leaf litter, stones, wood chips, etc., may be available at all sites due to drift, but these appeared only at the Disposal Site with regularity.

113. Of interest are the disposals which accidentally occurred at Station F8. Only a few dredge loads of material were placed on this site in 1976. Stomachs from postdisposal periods demonstrated some detrital material similar to that at Station F7. Table 13 demonstrates predisposal and postdisposal stomach contents pertaining to the presence of inorganic or detrital items ingested.

114. Obviously, fish captured in the Disposal Area were feeding there, although perhaps primarily on the fringes of the Disposal Site. This seems logical since chironomids and isopods were unavailable near the center of the Disposal Area. These two taxa were present in stomachs along with disposal detritus. It would appear that feeding occurs near the disposed material and probably less often on the disposal pile.

115. The appearance of certain organisms not normally associated with offshore fauna was also noted at Stations F7 and F8. These organisms appeared in very low numbers and contributed little to the total food intake. Their presence, however, supports the conclusions made from the detrital items found at these two sites. Table 14 demonstrates the presence of certain of these organisms during the 1975 postdisposal period. During the 1976 disposal operation foreign organisms were encountered only at the two Disposal Sites, F8 and F17. No organisms of this type were taken at the Control Area, Station F18. Detrital materials and foreign organisms clearly indicate that disposal materials are utilized as food, but also that their value to the total food intake is

extremely limited. Such items appear in trace quantities for as long as three months. This might indicate that survival of these materials may be available for considerable periods of time.

116. The only major effect of disposal observed during the course of this study was that of egg mortality at and in the vicinity of the Disposal Site. Studies of this impact were conducted only with a minimal effort during 1977 since this was not originally part of the study design. One-hundred percent mortality occurred within 250 m of the disposal and may indicate considerable egg mortality in a normal disposal operation from moving dredges disposing over a larger area.

117. The exact cause of mortality is unknown. It may be due to suffocation from burial in fine silts, toxicity from contact with polluted sediments, toxicity from resuspension of materials from dredged material, oxygen deficiency in bottom interstitial waters from oxygen demands, or a combination of these factors.

118. The total extent of mortality from disposal is unknown since no experimental egg chambers were placed at distances between 300-1600 m from the Disposal Site. Eggs at the Reference Stations F28 and F8 exhibited a high rate of survival (70-100%), thus demonstrating that the effect of disposal is contained within an area less than a circular mile.

119. Most species of fish present in the Ashtabula area spawn in the previously described "nearshore zone." Therefore, it is unlikely that any major negative effect would occur to them from a disposal at the 15-m contour. A few species, however, appear to spawn primarily in nearshore waters and partially in offshore waters (Table 20). These species spawn over or among gravelly, sandy, or rocky areas which might be present in offshore disposal areas. However, since disposal normally occurs in predetermined areas year after year, and since impact seems to be limited to a radius of < 1600 m, the impact on the total population would probably be minimal. Selection of new disposal sites, however, is an important consideration. These sites should be selected in areas where a silty mud substrate already exists and at depths of > 12 m.

120. The impact of disposal on other aspects related to the fishery were either nonexistent or of very short duration. No change could be documented in the abundances (Table 21), growth rate, or age structure of the yellow perch, smelt, gizzardshad, or drum that were not within normal variation in Lake Erie. Since populations of these species are highly mobile and probably homogenous in the offshore areas, this result was not surprising.

121. Eggs or larvae of fish species should not be present in the Disposal Area after August. Few adult demersal fish species are present, and feeding behavior during the August-October period seems to be centered on pelagic food items. It would appear that any possible impact would be lessened if disposal occurs during this period of the year.

PART V: SUMMARY AND CONCLUSIONS

122. The effect of dredged material on the nektonic (fish) fauna varied depending upon the species and life history stage examined. These responses ranged from only slight avoidance of the disposal event for < 2 min, to one of total mortality within 250 m of the Disposal Site. Therefore, effects discussed below have been arranged by effect groupings rather than taxonomy.

123. In most cases, the effect of the disposal operation was so slight and lasted for such a short period of time that it was difficult to observe. Such is the case with the surface and mid-water dwelling species of nekton. The response of fish such as rainbow smelt, emerald shiner, eastern gizzardshad, and alewife was simply to move away from the initial hopper disposal and then to enter the plume of suspended material as soon as the dredge moved from the site. There was no indication of avoidance or attraction of these species to the Disposal Site. Within 10 min after disposal, these species appeared in equal concentrations at the site of disposal and in areas surrounding the Disposal Site. At longer periods after disposal (5-90 days), populations of these species were equally distributed at Disposal, Near Disposal, and Reference Sites, indicating a lack of any long-term effect as well.

124. Nektonic species which were associated with bottom habitats (yellow perch, trout-perch) exhibited a negative response to the initial portion of the disposal event. This was apparently a response to the shock wave and plume distributed along the bottom. These species withdrew from the areas to a new location. Evidence indicates that these individuals moved to a point at least 500 m distant. Fathometer recordings at sites 500 m from the Disposal Site indicated similar fish concentrations before, during, and immediately after the disposal event.

125. This initial response was very short-lived, however, for within 10 min after disposal, concentrations of bottom-dwelling fish were similar at all sites, including the Disposal Area. No concentration effect was observed at any of the Disposal Sites during any period after disposal.

The effect of the disposal operation on adult nektonic organisms may thus be summarized as ranging from slight avoidance of the initial disposal to a minimal negative response lasting < 15 min. No long-term avoidance or attraction was observed.

126. Larval populations of surface or mid-water dwelling forms (primarily emerald shiner and smelt) are essentially planktonic and, thus, were difficult to investigate. This is because the mixing and dilution of plume material and the current patterns of the study area made it impossible to sample repeatedly those specific larvae present at the point of disposal. Samples at the Disposal Site, Reference Sites, and sites 500 m from the point of disposal were all similar. As with the plankton, it would be necessary to perform studies similar to elutriate tests on fish larvae before positive statements could be made concerning the effect of plume.

127. Bottom-dwelling fish larvae were not investigated. This was due to the difficulty in sampling over rocky or soft mud substrates with larva trawls. It is suggested that a pumping device be utilized to sample these organisms at some future time.

128. The effect of disposal on fish eggs was investigated using an in situ bioassay technique. Rainbow trout eggs suffered 100% mortality at all test sites within 250 m of the 1976 Disposal Site. A survival-to-hatching rate of 89.7% was documented at the Reference Station. Eggs placed at Station F8 suffered only a 37% mortality. This site was chosen to examine the long-term effect of disposal material since this site was used in 1975. However, at least two disposal events were observed at this site during the study period. This new material may have been the cause of the mortality which was observed.

129. The cause of the mortality at the 1976 Disposal Site was probably siltation of the eggs, either from the initial settling of the material or from erosion and drift of the disposal mound. Those experimental boxes placed within 50 m of the Disposal Site buoy contained nearly 16 cm of silt. The platforms also were silted over, indicating that the egg boxes had not merely trapped drifting material. Boxes more distant from the disposal buoy contained progressively less silt, but

even at 250 m, more than 3 cm of silt covered the eggs. Many Lake Erie species lay their eggs in sand, gravel, or stones, and it is certain that these eggs would suffer 100% mortality within at least a 250 m radius of a Disposal Site. Survival of eggs at Station F8 1.6 km (1 mile) from the Disposal Area indicates that silts and muds drifting from the Disposal Area have little effect. It is probable that beyond approximately 300 m the lethal effect of these particulates diminishes. However, if disposal occurs from a moving vessel, at various points during the disposal period, the scattering of less material over a wider area would probably result in significantly higher loss of fish productivity from egg mortality.

130. In addition to the effect of direct siltation, it is possible that toxic materials released at the site of disposal could also cause egg mortality. Since all eggs were covered with silts, it is not possible to discuss this effect, but it is probable that an effect would be observed when disposing highly polluted sediments.

131. Long-term effects were not noted in either adult, young, or larval nektonic species. During postdisposal periods, monthly collections indicated that populations were similar at the two 1975 Disposal Sites and the Reference Site. Those collections taken in 1976 indicated that 1975 sites remained similar to the Reference Area. Postdisposal and predisposal collections in 1976 at three disposal and one reference station again indicated similarity.

132. Population structure and species abundance exhibited similar trends during 1975 and 1976.

133. It was apparent that long-term effects on the adults, young-of-the-year, and fry were negligible.

134. A great dissimilarity in species composition abundance and production was observed between all offshore stations and the onshore study sites. The offshore areas were inhabited by relatively few (20) species compared to the onshore stations (44 species). Many species (25) were never collected in areas near the Disposal or Reference Sites. This would indicate that the major population of a great many species lives in the area < 3 km from shore as both adults and young-of-the-year.

135. Larval populations also exhibited this trend but to an even

greater degree. Only smelt and emerald shiner were collected with regularity in the offshore Disposal or Reference area, while 26 species, many in abundance, were taken in nearshore (< 3 km) areas.

136. The obvious conclusion of these investigations is that a disposal event which occurs > 3 km from shore has far less chance of causing negative impacts than an event within the nearshore zone. Since most of the larvae collected were taken within the nearshore zone, it may be assumed that most spawning also occurs there, thus lessening the probability of great negative impact due to egg mortality in offshore areas.

137. Studies in 1975 and 1976 by Hubbard (1977) within the Ashtabula Harbor indicated significant production of larvae in areas that were dredged. Most of the larva collected were smelt, gizzardshad, emerald shiners, and spottail shiners, although lesser numbers of other species were collected. It is possible that the dredging operation might have a negative effect on these species at this point in the program.

138. Yellow perch, rainbow smelt, and trout-perch were the most abundant species captured in the offshore areas. Age composition of the populations of these three species remained similar between sites during all months of collection. The yellow perch population consisted almost entirely of age class 1+ through 3+ individuals, while rainbow smelt of all age classes were collected consistently. Trout-perch populations consisted primarily of 2+ and 3+ individuals, although 1+ specimens were collected in trawls. No 0+ individuals were captured of either yellow perch or trout-perch.

139. The feeding behavior of offshore (depths > 7.5 m) and onshore populations of yellow perch was investigated to determine the extent of diurnal feeding migrations. Stomach contents of offshore individuals consistently were different from onshore individuals. Stomach contents from offshore individuals included primarily isopods, leeches, chironomids, and young fishes. Specimens from nearshore areas fed on a wide variety of items, including snails, crayfish, tricopterans, dragonfly nymphs, gammarids, and many others. Fish was also an important part of the nearshore food items, but where it could be determined, the fish species were

highly variable. These included ictalurids, sculpins, alewife, emerald shiners, spottail shiners, smelt, gizzardshad, and others. Fish present in the stomachs of offshore individuals were almost entirely smelt and gizzardshad. It was concluded from these data that diurnal migrations to nearshore feeding grounds were minimal; therefore, it was assumed that major feeding differences between Disposal or Reference Sites would represent real feeding behavior changes.

140. The results of this study suggested:

a. The impact of a disposal event on adult and young-of-the-year nektonic organisms is limited to a short-term avoidance of the physical disturbance. Mid-water and surface-dwelling species enter the plume created by the disposal event with little or no apparent avoidance. Bottom-dwelling species move from the Disposal Area to a location at least 300 m distant and return to the Disposal Site within a period of < 1 hr.

b. Long-term avoidance or attraction of nektonic organisms was not observed. It is probable that no response to the pile of disposed material can be documented.

c. Feeding behavior of offshore demersal species is based principally on chironomids, isopods, leeches, snails, and smaller fishes. A short-term effect was noticed at the Disposal Sites in that foreign species and disposed detritus were present in the Disposal Area fishes. It is probable, however, that these were fed upon merely because they were available, not because a feeding attraction was occurring. This effect was observed only for a short period of time.

d. Fish populations are highest in the Disposal Area during June-July and lowest during August. This would indicate that the least impact would be possible during late August through September.

e. Most spawning and nursery activity in the Ashtabula area is centered along the nearshore zones from the shoreline to the 7.5 m contour (about 1.6-3 km). Breakwall areas and protected waters such as marinas are highly productive. There is little or no use of mud substrates in offshore areas. Thus, disposal over mud substrates > 3 km offshore would have a minimal impact on fish production.

f. No changes in community structure or population size could be documented for offshore sites during postdisposal studies. Fish populations are highly mobile in the offshore areas, are foraging over large areas, and are not greatly impacted

by a limited area of disposed material.

g. Changes in meiobenthic, oliogchaete, or bottom zooplanktonic populations have little direct effect on offshore nektonic populations. These offshore fishes feed only rarely on oligochaetes and only gizzardshad feed on bottom muds containing algae, meiobenthos, or zooplankton. Shad are indiscriminate feeders; thus, changes do not create any discernible effect.

h. Isopod and chironomid populations changed in the area of disposal but no long-term change or shift could be ascertained in the feeding behavior of the fish fauna. However, the possibility of short-term toxic substance uptake by fish feeding in the Disposal Area should be considered.

i. Mortality of demersal fish eggs was 100% in areas within 250 m of the point of disposal. No effect of disposal on eggs > 1 mile from Disposal Sites was observed. The effect of suspended particles or toxic materials on fish larvae was not determined but should be considered to be a potential problem.

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TABLE 1

Nearshore and Offshore Fish Species in 1976-1977

Species	Nearshore	Offshore
Alewife	x	x
E. Gizzardshad	x	x
Rainbow Smelt	x	x
E. Burbot	x	x
Longnose Gar	x	
Coho Salmon	x	x
Northern Pike	x	
White Sucker	x	x
Black Redhorse	x	
Golden Redhorse	x	
Northern Redhorse	x	
Quillback	x	
Carp	x	x
Goldfish	x	
Carp X Goldfish	x	
Goldenshiner	x	
Emerald Shiner	x	x
Spottail Shiner	x	x
Spotfin Shiner	x	
Sand Shiner	x	
Longnose Dace	x	
Bluntnose Minnow	x	
Stonecat Madtom	x	x
Channel Catfish	x	x
Black Bullhead	x	
Yellow Bullhead	x	
Brown Bullhead	x	
White Bass	x	x
E. Banded Killifish	x	
Trout-perch	x	x
White Crappie	x	
Black Crappie	x	
N. Rockbass	x	x
Smallmouth Blackbass	x	x
Largemouth Blackbass	x	
Green Sunfish	x	
Bluegill Sunfish	x	
Pumpkinseed Sunfish	x	
Sauger		x
Walleye	x	x
Yellow Perch	x	x

(CONTINUED)

Table 1 (Concluded)

Species	Nearshore	Offshore
Logperch Darter	x	
Scaley Johnny Darter	x	
Freshwater Drum	x	x
Northern Mottled Sculpin	x	x
Total Number	44	20

TABLE 2

Species Composition and Abundance
at Five Ashtabula Area Study Sites,
Gill Nets Only

Species	Stations F7	F8	F17	F18	F28
Alewife	.31	4.62	9.53	3.07	6.26
Gizzardshad	.31	7.17	9.14	3.75	5.01
Coho Salmon	-	-	-	.11	-
Rainbow Smelt	1.24	2.57	1.31	5.29	.53
Northern Pike	-	-	-	-	.07
Carp	.21	.61	1.30	.23	2.50
Goldfish	-	-	-	-	.20
Emerald Shiner	*	*	*	*	*
Spottail Shiner	-	.21	.13	.06	.13
Quillback	-	-	-	-	.46
Black Redhorse	-	-	-	-	.07
Golden Redhorse	-	-	-	-	.33
Northern Redhorse	-	-	-	-	.13
White Sucker	1.14	.72	2.22	.40	6.46
Channel Catfish	-	-	.13	-	.26
Stonecat Madtom	-	.51	.26	.17	4.28
Burbot	.21	.41	.28	-	-
Trout-perch	.83	1.54	1.44	1.14	.53
White Bass	-	.21	.26	.46	2.11
White Crappie	-	-	-	-	*
Black Crappie	-	-	-	-	*
Rockbass	.10	.10	-	-	1.25
Smallmouth Blackbass	-	-	-	.06	.13
Bluegill Sunfish	-	-	-	-	*
Sauger	-	.21	.65	-	.07
Walleye	-	.72	.39	.11	1.71
Yellow Perch	91.73	74.31	66.58	78.90	62.85
Logperch Darter	-	-	-	-	*
Scaley Johnny Darter	-	-	-	-	*
Freshwater Drum	3.93	5.55	6.66	5.97	4.74
Northern Mottled Sculpin	-	-	-	-	*

* Collected by trawls; not figured in gill net abundances

TABLE 3

Egg Mortality and Container Conditions at All Ashtabula Study Locations

Station	Mortality Rate (%)	Silt Accumulation (cm)
F28	0.0	0.0
F18	10.7	0.0
F8 + 100 m SE	37.4	<0.1
F7 + 200 m SE	100.0	.5
F7 + 150 m SE	100.0	1.8
F7 + 100 m SE	100.0	16.0

TABLE 4

Ashtabula Fisheries Study
Food Items from Stomach Contents of All Species

BENTHIC ORGANISMS

HIRUDINEA

Pisicolidae
Helobdella sp.
Helobdella stagnalis
Helobdella elongatum

ACARI

Hydracarina sp.

OLIGOCHAETA

Unidentified Oligochaetes

OSTRACODA

Ostracoda

ISOPODA

Asellidae
Asellus sp.
Asellus racovitzai
Asellidae eggs

AMPHIPODA

Gammarus fasciatus
Gammarus sp.
Hyallella azteca

GASTROPODA

Amnicola limosa
Bithnia eggs
Bithnia tentaculata
Physa sp.
Goniobasis
Vivipara japonicum
Valvata sp.
Valvata sincera
Valvata lewisi
Valvata tricarinata
Unidentified gastropoda

SPHAERIIDAE

Sphaerium (Musculum) sp.
Pisidium sp.

TRICOPTERA

Athripsodes sp.
Athripsodes alagmus
Hydropsychidae
Leptoceridae
Hydroptilidae
Oxyethira sp.
Unidentified tricoptera

COLEOPTERA

Gyrinus sp.

ODONATA

EPHEMEROPTERA

Heptageniidae
Stenonema sp.

HYMENOPTERA

Formicidae

HOMOPTERA

Cicadellidae
Aphidae

DIPTERA

Chironomidae
Chironomus sp. (adult)
Chironomus sp.
Cryptochironomus sp.
Orthocladius sp.
Procladius sp.
Tanytarsus sp.
Diptera
Ceratopogonidae
Culicoidinae
Tipulidae
Spaniotoma sp.

(CONTINUED)

TABLE 4 (CONTINUED)

BENTHIC ORGANISMS (CONTINUED)

PLECOPTERA

INSECTA

Unidentified Insect Parts

DECAPODA

Orconectes propinquus
Orconectes sp.
Orconectes obscurus
Orconectes immunis

NEKTONIC ORGANISMS

VERTEBRATA

Alosa pseudoharengus
Dorosoma cepedianum
Ictaluridae
Percina caprodes
Morone chrysops
Osmerus mordax
Notropis sp.
Notropis hudsonius
Notropis atherinoides
Cottus bairdi
Aplodinotus grunniens
Perca flavescens
Percopsis omiscomaycus
Unidentified fish fry
Fish eggs
Perca flavescens eggs
Notropis atherinoides eggs
Fish remains (unidentified)

ZOOPLANKTON ORGANISMS

CLADOCERA

Chydorus sp.
Alona sp.
Chydorus sphaericus
Ceriodaphnia sp.
Daphnia sp.
Daphnia galeata mendotae
Daphnia pulex (Magna)
Daphnia longispina
Daphnia retrocuruata
Bosminidae
Bosmina coregoni
Bosmina longirostris
Leptodora kindtii

COPEPODA

Nauplii
Cyclopoida
Calanoida
Unidentified Copepoda
Paracyclops sp.
Harpactacoid copepods
Cyclopoid copepods
Orthocyclops modestus

ROTIFERA

Polyarthra sp.
Polyarthra vulgaris
Rotifera
Tricocera sp.
Keratella quadrata
Keratella cochlearis

(CONTINUED)

TABLE 4 (CONCLUDED)

PHYTOPLANKTON ORGANISMS

CHLOROPHYTA

- *Cosmarium*
- *Closterium*
- *Staurastrum*
- *Closteriopsis*
- *Kirchneriella*
- *Oocystis*
- *Nephrocytium*
- Unidentified green alga
- *Coelastrum*
- *Scenedesmus*
- *Pediastrum*
- Cladophora
- *Ceratium*

CYANOPHYTA

- *Coelosphaerium*
- *Anabaena*
- *Oscillatoria*

BACILLARIOPHYCEAE

- *Asterionella*
- *Fragillaria*
- *Stephanodiscus*
- *Tabellaria*

RHIZOPODA

- *Difflugia* sp.
- *Difflugia globosa*
- *Difflugia urceola*

VASCULAR PLANTS

- *Elodea* sp.

MISCELLANEOUS STOMACH ITEMS

- Animal detritus
- Plant detritus
- Asphalt
- Bark chips
- Coal
- Crude oil
- Gravel
- Leaf litter
- Mud
- Pebbles
- Vascular plant seeds
- Sand
- Thread
- Wood chips
- Sticks

TABLE 5

Number of Fish Stomachs Examined in 1975-1976

All Species

Species	Common Name	# Stomachs Examined
Lepisosteus osseus	Longnose Gar	0
Alosa pseudoharengus	Alewife	176
Dorosoma cepedianum	Eastern Gizzardshad	125
Oncorhynchus kisutch	Coho Salmon	3
Osmerus mordax	Rainbow Smelt	111
Esox lucius	Northern Pike	1
Cyprinus carpio	Carp	39
Cyprinus X Carassius	Carp X Goldfish Hybrid	7
Carassius auratus	Goldfish	1
Notemigonus crysoleucas	Goldenshiner	0
Rhinichthyes cataractae	Longnose Dace	0
Notropis atherinoides	Emerald Shiner	0
Notropis hudsonius	Spottail Shiner	6
Notropis spilopterus	Spotfin Shiner	0
Notropis stramineus	Sand Shiner	0
Pimephales notatus	Bluntnose Minnow	0
Carpiodes cyprinus	Quillback	5
Moxostoma duquesnei	Black Redhorse	1
Moxostoma erythrurum	Golden Redhorse	6
Moxostoma macrolepidotum	Northern Redhorse	3
Catostomus commersoni	White Sucker	128
Ictalurus punctatus	Channel Catfish	6
Ictalurus natalis	Yellow Bullhead	0
Ictalurus nebulosus	Brown Bullhead	0
Ictalurus melas	Black Bullhead	0
Noturus flavus	Stonecat Madtom	66
Fundulus diaphanus	Eastern Banded Killifish	0
Lota lota	Eastern Burbot	1
Percopsis omiscomaycus	Trout-perch	59
Morone chrysops	White Bass	34
Pomoxis annularis	White Crappie	0
Pomoxis nigromaculatus	Black Crappie	0
Micropterus dolomieui	Smallmouth Bass	3
Micropterus salmoides	Largemouth Bass	0
Lepomis cyanellus	Green Sunfish	0
Lepomis macrochirus	Bluegill Sunfish	0
Lepomis gibbosus	Pumpkinseed Sunfish	0
Stizostedion canadense	Sauger	7
Stizostedion v. vitreum	Walleye	27

(CONTINUED)

TABLE 5 (CONCLUDED)

Species	Common Name	# Stomachs Examined
Perca flavescens	Yellow Perch	3983
Percina caprodes	Logperch Darter	0
Etheostoma nigrum eulepis	Scaley Johnny Darter	0
Aplodinotus grunniens	Freshwater Drum	325
Cottus bairdi kumleini	Northern Mottled Sculpin	0
Ambloplites rupestris	Rockbass	14

Total Species Collected = 44

Total Species Examined for Stomach Contents = 24

Total Stomachs Examined = 5137

Table 6

Feeding Behavior of Alewife
in the Ashtabula, Ohio, Area
1975 - 1976

Prey Species	# Stomachs Present	% by Number	% by Volume
AMPHIPODA			
Gammarus sp.	1	<.01	.01
MOLLUSCA			
Valvata sp.	1	<.01	.06
DIPTERA			
Chironomus sp.	5	.01	.21
COLEOPTERA			
Uniden. Adult Coleoptera	1	<.01	<.01
TRICOPTERA			
Uniden. Tricoptera	6	<.01	2.06
EPHEMEROPTERA			
Heptageniidae	3	.01	.87
OSTRACODA			
Uniden. Ostracods	1	<.01	<.01
CLADOCERA			
Uniden. Cladocera	69	8.13	9.68
Chydorus sp.	8	.06	.01
Alona sp.	2	.01	.01
Ceriodaphnia sp.	12	.22	.13
Daphnia sp.	82	14.12	24.05
Daphnia galeata	3	.09	.35
Daphnia pulex	1	<.01	.01
Bosminidae	77	9.31	4.38
Bosmina coregoni	65	3.30	1.70
Bosmina longirostris	65	2.70	1.75
Leptodora sp.	40	1.43	21.53
COPEPODA			
Nauplii	2	.01	<.01
Cyclopoida	82	20.33	8.65
Calanoida	88	16.41	10.73
Uniden. Copepods	100	23.34	13.52

(CONTINUED)

TABLE 6 (CONCLUDED)

Prey Species	# Stomachs Present	% by Number	% by Number
ROTIFERA			
Keratella quadrata	2	.01	<.01
Keratella cochlearis	1	<.01	<.01
RHIZOPODA			
Difflugia urceola	3	.32	<.01
CHLOROPHYTA			
Pediastrum sp.	14	.17	.28
Ceratium sp.	2	.01	.02
Scenedesmus sp.	1	<.01	<.01
BACILLARIOPHYCEAE			
Stephanodiscus sp.	1	<.01	<.01

Total Stomachs Examined = 176

Total Stomachs Empty = 30

Total Stomachs Ruptured = 37

TABLE 7

Feeding Behavior of Eastern Gizzardshad in the Ashtabula, Ohio, Area

Prey Species	# Stomachs Present	# Prey Present	% by Number
AMPHIPODA			
Uniden. Amphipoda	2	2	<.01
MOLLUSCA			
Bithinia sp.	1	1	<.01
OSTRACODA			
Uniden. Ostracods	1	10	.01
ACARI			
Hydracarina sp.	1	3	<.01
CLADOCERA			
Alona sp.	1	48	.04
Daphnia sp.	11	795	.71
Bosminidae	21	5,538	4.94
Bosmina longirostris	4	46	.04
Bosmina coregoni	2	108	.10
Leptodora sp.	6	233	.21
Uniden. Cladocera	18	3,935	3.51
COPEPODA			
Cyclopoida	3	104	.09
Calanoida	12	337	.30
Harpactacoida	2	6	.01
Uniden. Copepods	19	927	.83
ROTIFERA			
Uniden. Rotifers	1	1	<.01
Keratella chchlearis	13	1,013	.90
Keratella quadrata	2	33	.03
RHIZOPODA			
Difflugia urceola	2	68	.06
CHLOROPHYTA			
Cosmarium sp.	3	674	.60
Closterium sp.	3	210	.19
Staurastrum sp.	18	7,416	6.61
Closteriopsis sp.	1	1	<.01
Kirchneriella sp.	1	1	<.01
Oocystis sp.	2	2	<.01
Coelastrum sp.	3	3	<.01
Scenedesmus sp.	5	5	<.01

TABLE 7 (CONCLUDED)

Prey Species	# Stomachs Present	# Prey Present	% by Number
CHLOROPHYTA (Cont.)			
Pediastrum sp.	24	86,326	76.96
Cladophora sp.	2	2	<.01
Ceratium sp.	3	34	.03
Uniden. Green Algae	1	64	.06
CYANOPHYTA			
Coelosphaerium sp.	1	1	<.01
Anabaena sp.	1	1	<.01
Oscillatoria	1	1	<.01
BACILLARIOPHYCEAE			
Asterionella sp.	1	1	<.01
Fragillaria sp.	6	21	.02
Stephanodiscus sp.	3	4,194	3.74
MISCELLANEOUS DETRITUS			
Sand	1		
Coal Chips	1		

Stomachs Examined = 125

Stomachs Empty = 13

Stomachs Ruptured = 85

Table 8

Feeding Behavior of Rainbow Smelt
in the Ashtabula, Ohio, Area

1975 - 1976

Prey Species	# Stomachs Present	% by Number	% by Volume
AMPHIPODA			
Gammarus sp.	6	.08	1.19
Hyalella sp.	1	.01	.07
MOLLUSCA			
Amnicola sp.	3	.11	.16
Valvata sp.	2	.03	.05
Sphaerium sp.	2	.08	1.00
Psidium sp.	1	.09	.97
DIPTERA			
Chironomus sp.	5	.10	1.13
Procladius sp.	4	.25	.47
Uniden. Chironomidae	1	.01	.30
OSTRACODA			
Uniden. Ostracods	1	.01	<.01
OLIGOCHAETA			
Uniden. Oligochaetes	1	.01	.01
CLADOCERA			
Uniden. Cladocera	3	1.46	.09
Daphnia sp.	8	73.40	4.71
Bosminidae	2	.06	<.01
Bosmina coregoni	1	14.12	.62
Bosmina longirostris	1	1.69	.03
COPEPODA			
Uniden. Copepoda	4	1.68	.06
Cyclopoida	2	1.84	.07
Calanoida	3	2.76	.07
Leptodora sp.	3	.27	.24
ISOPODA			
Asellus sp.	9	1.75	17.18
Invertebrate Eggs	1	.12	.07
VERTEBRATA			
Osmerus Mordax	6	.07	45.47
Notropis Atherinoides	1	.01	26.04

(CONTINUED)

TABLE 8 (CONCLUDED)

Prey Species	# Stomachs Present	% by Number	% by Volume
Miscellaneous Detritus	1	.01	<.01

Total Stomachs Examined = 111

Total Stomachs Empty = 69

Total Stomachs Ruptured = 16

TABLE 9

Feeding Behavior of Trout-Perch
in the Ashtabula, Ohio, Area

1975 - 1976

Prey Species	# Stomachs Present	% by Number	% by Volume
ISOPODA			
Asellus sp.	29	18.15	18.23
AMPHIPODA			
Gammarus sp.	20	13.33	20.14
Hyalella sp.	3	.47	.41
HIRUDINEA			
Helobdella sp.	6	5.10	16.48
OLIGOCHAETA			
Uniden. Oligochaetes	1	2.55	.41
DIPTERA			
Chironomus sp.	31	49.72	38.73
Procladius sp.	15	7.94	2.59
Orthocladius sp.	2	.85	.16
Tanytarsus sp.	3	.47	.04
Uniden. Chironomids	3	1.23	1.35
EPHEMEROPTERA			
Uniden. Ephemeroptera	1	.09	.28
Animal detritus	1	.09	1.28

Total Stomachs Examined = 59

Total Stomachs Empty = 9

Total Stomachs Ruptured = 8

TABLE 10

Feeding Behavior of the Freshwater Drum
in the Ashtabula, Ohio, Area
1975 - 1976

Prey Species	# Stomachs Present	% by Number	% by Volume
ISOPODA			
Asellus sp.	66	61.58	14.15
Asellus sp. eggs	1	.05	<.01
AMPHIPODA			
Gammarus sp.	20	2.58	1.95
Hyalella sp.	2	.12	.09
Uniden. Amphipods	4	.40	.30
HIRUDINEA			
Helobdella sp.	11	1.12	7.11
OLIGOCHAETA	4	.39	.04
MOLLUSCA			
Sphaeriidae	2	.14	.23
Bithnia sp.	4	12.47	9.03
Amnicola sp.	1	.02	.01
Valvata sp.	3	2.39	2.15
Uniden. Gastropods	3	1.45	4.85
DIPTERA			
Chironomus sp.	37	4.96	1.79
Procladius sp.	33	9.72	1.11
Tanytarsus sp.	1	.02	<.01
Uniden. Chironomids	2	.22	.03
Tipulidae	1	.02	.01
TRICOPTERA			
Uniden. Tricoptera	5	.16	.09
Miscellanous Insects	1	.03	.01
DECAPODA			
Astacidae (*Orconectes* sp.)	4	.09	22.30
CLADOCERA			
Leptodora sp.	2	.05	.05
Daphnia sp.	1	.12	.01
Uniden. Cladocera	1	.50	<.01

(CONTINUED)

TABLE 10 (CONCLUDED)

Prey Species	# Stomachs Present	% by Number	% by Volume
COPEPODA			
Uniden. Copepods	1	.25	<.01
VERTEBRATA			
Fish Remains	1	.02	2.13
Osmerus mordax	10	.37	8.10
Precopsis omiscomaycus	1	.02	7.48
Uniden. Fish	3	.05	1.85
CHLOROPHYTA			
Pediastrum sp.	1	.25	<.01
Miscellaneous Material			
Plant detritus	6	.11	.50
Animal detritus	6	.09	14.00
Wood chips	1	.02	<.01
Leaf litter	2	.03	<.01
Uniden. detritus	1	.02	.57
Invertebrate eggs	5	.20	.04

Total Stomachs Examined = 325

Total Stomachs Empty = 120

Total Stomachs Ruptured = 93

TABLE 11

Monthly Percent of Total Volume
Yellow Perch - Offshore Sites

Month	Asellus (%)	Chironomidae (%)	Hirudinea (%)	Gastropoda (%)	Amphipoda (%)	Fish (%)
June 1975	73.26	20.95	2.38	0.20	0.17	2.60
July 1975	3.60	0.23	0.96	0.03	2.22	71.76
Aug. 1975	0.02	21.24	0.00	0.00	0.13	76.20
Sept. 1975	1.18	3.30	5.32	42.28	0.63	29.11
Oct. 1975	20.16	0.29	4.27	6.25	0.32	67.17
Nov. 1975	68.86	1.47	7.46	0.10	0.77	21.17
Mar. 1976	95.15	0.75	4.10	0.00	0.37	0.00
Apr. 1976	69.13	7.35	3.92	0.02	8.09	8.02
May 1976	30.83	12.30	2.59	0.06	5.67	18.12
June 1976	8.57	74.15	7.87	0.00	3.89	0.00
July 1976	5.84	4.22	4.54	2.18	4.19	73.02

TABLE 12

Indicator "Tag" Organisms from Offshore and Onshore Stomach Analyses

Onshore Analyses	Offshore Analyses
Decapoda	Isopoda
Orconectes sp.	*Asellus* sp.
Cryptochironomis	
Plecoptera	
Ephemeroptera	
Tricoptera	
Athripsodes sp.	
Hydropsychidae	
Leptoceridae	
Odonata	
Hydracarina	
Gastropoda	
Bithnia sp.	
Goniobasis sp.	
Physa sp.	
Ostracoda	

TABLE 13

Detrital Material from Offshore Yellow Perch Stomachs

Period	Station F7	Station F8	Station F17	Station F18
Predisposal	None	Sand	Lake Pebbles Sand Gravel	Sand
Postdisposal	Plant Detritus Leaf Litter Bunker Oil Dead Fish Wood Chips Slag Asphalt	Plant Detritus Leaf Litter Dead Fish Wood Chips	None	Plant Detritus

TABLE 14

Nearshore Organisms in Offshore Yellow Perch Stomachs

Period	Station F7	Station F8	Station F17	Station F18
Pre-disposal 1976	None	None	None	Plecoptera Hydracarina
Pre-disposal 1977	None	None	None	None
Post-disposal 1976	None	Tricoptera Ostracods Cicadellidae Athripsodes Bithinia Formicidae	Tricoptera Odonata	None
Post-disposal 1977	Bithnia Hydracarina Ephemeroptera Cryptochironomus Tricoptera	Hydracarina Tricoptera Cryptochironomus	None	Tricoptera Cryptochironomus

Table 15

Volumetric Intake of Food Items at Reference and Disposal Sites During the Postdisposal Period - 1976

Food Item	Station F18 % of Total	Station F7 % of Total
Asellus sp.	9.85	14.42
Gammarus sp.	.93	5.20
Hyalella sp.	.01	.21
Unidentified Amphipods	.01	.03
Unidentified Chironomids	.02	
Chironomus sp.	33.74	50.98
Procladius sp.	6.20	3.11
Tanytarsus sp.	.03	.01
Cryptochironomus sp.	<.01	<.01
Orthocladius sp.	.01	Not present
Unidentified Gastropods	.01	
Bithnia sp.	0	.01
Valvata sp.	.23	.01
Physa sp.	.06	.27
Unidentified Sphaeridae	.36	
Sphaerium sp.	.03	.02
Psidium sp.	.04	Not present
Helobdella sp.	9.47	3.45
Ephemeroptera	Not present	<.01
Tricoptera	<.01	<.01
Invertebrate eggs	<.01	Not present
Daphnia sp.	<.01	.04
Daphnia galeata		<.01
Cladocera	.22	<.01
Bosminidae	<.01	Not present
Bosmina coregoni	<.01	<.01
Bosmina longiremus	<.01	<.01
Leptodora sp.	2.69	Not present
Calanoida	<.01	<.01
Cyclopoida	<.01	
Unidentified Copepods	<.01	
Hydracarina	Not present	.01
Unidentified Osteichthyes	35.07	28.63
Fish eggs	Not present	.37
Aplodinotus sp.		<.01
Osmerus sp.	.82	.90
Alosa sp.		.42
Notropis sp.	.04	

(CONTINUED)

TABLE 15 (CONCLUDED)

Food Item	Station F18 % of Total	Station F7 % of Total
Plant Detritus	<.01	1.29
Animal Detritus	.15	.35
Bunker Oil	Not present	.21
Leaf Litter	Not present	.01
Wood Chips	Not present	.04
Slag	Not present	<.01
Asphalt	Not present	<.01

Table 16

Benthic Food Items In
Yellow Perch Stomachs - 1976

Station F18

	Predisposal			Postdisposal		
	#	%	mℓ	#	%	mℓ
ASELLIDAE	2831	79	24.54	1,690	14	13.54
CHIRONOMIDAE	642	18	3.77	10,387	83	55.02
Chironomus	289	(97)	3.03	7,262	(97)	46.40
Procladius	329		.71	3,089		8.53
Tanytarsus	16		.01	24		.05
Orthocladius	2		.01	5		.01
Uniden. Chironomids	6		.01	7		.03
HELOBDELLA	45	1	2.28	209	2	13.03
AMPHIPODA	56	1	1.44	144	1	1.32
Gammarus sp.	54		1.42	141		1.28
Uniden. Amphipoda	2		.02	1		.02
Hyalella sp.				2		.02
SPHAERIDAE	4	<1	.06	21	<1	.59
Psidium sp.	1		.01	5		.06
Sphaerium sp.	3		.05	5		.04
Uniden. Sphaeridae				11		.49
GASTROPODA	2	<1	<.01	11	<1	.42
Uniden. Gastropoda	1		<.01	1		.02
Valvata sp.	1		<.01	7		.32
Physa sp.				3		.08

TABLE 17

Benthic Food Items in
Yellow Perch Stomachs - 1976

Station F7

	Predisposal			Postdisposal		
	#	%	mℓ	#	%	mℓ
ASELLIDAE	1033	56	7.83	2030	19	16.42
CHIRONOMIDAE	743	40	2.97	7862	74	61.64
Chironomus sp.	695	(96)	2.91	6389	(91)	58.08
Procladius sp.	40		.06	1463		3.54
Tanytarsus sp.	1		<.01	7		.02
Orthocladius sp.						
Uniden. Chironomids	7		.03	3		<.01
HELOBDELLA	3	<1	.39	73	1	3.93
AMPHIPODA	80	4	1.00	664	6	6.2
Gammarus sp.	60		.73	641		5.92
Uniden. Amphipoda				6		.04
Hyalella sp.	20		.27	17		.24
SPHAERIDAE		0		4	<1	.02
Psidium sp.						
Sphaerium sp.				4		.02
Uniden. Sphaeridae						
GASTROPODA		0		8	<1	.32
Uniden. Gastropoda						
Valvata sp.				6		.01
Physa sp.				2		.31
Bithnia sp.	2		.01			

TABLE 18

Benthic Food Items in
Yellow Perch Stomachs - 1976

Station F8

	Predisposal			Postdisposal		
	#	%	mℓ	#	%	mℓ
ASELLIDAE	1592	72	15.34	2421	26	8.10
CHIRONOMIDAE	482	22	6.54	6439	70	42.32
Chironomus sp.	139	(94)	5.90	5489	(96)	40.10
Procladius sp.	323		.61	935		2.19
Tanytarsus sp.	12		.01	12		.02
Orthocladius sp.	1		.01			
Uniden. Chironomids	7		.01	3		.01
HELOBDELLA	12	1	1.26	57	1	4.16
AMPHIPODA	118	5	7.32	291	3	2.58
Gammarus sp.	112		7.18	279		2.41
Uniden. Amphipoda						
Hyalella sp.	6		.14	12		.17
SPHAERIDAE	4	<1	.04	6	<1	.07
Psidium sp.	3		.03	1		.01
Sphaerium sp.	1		.01	5		.06
Uniden. Sphaeridae						
GASTROPODA	5	<1	.05	1	<1	<.01
Uniden. Gastropoda						
Valvata sp.	4		.05	1		<.01
Physa sp.						
Amnicola sp.	1		<.01			

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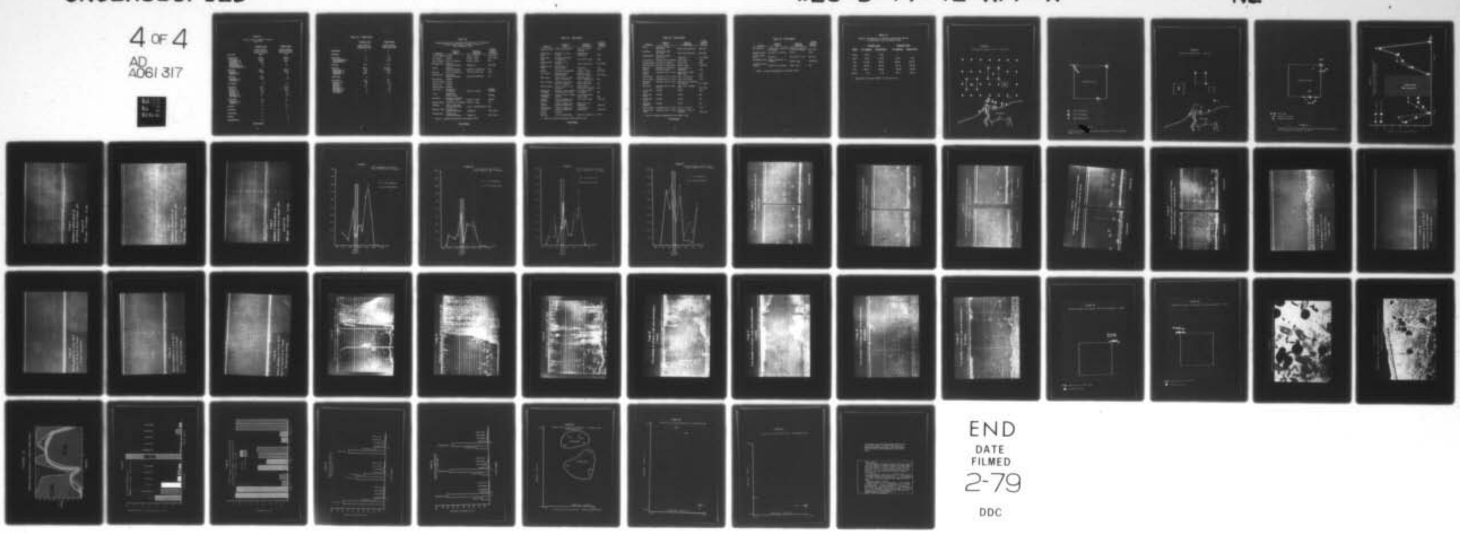

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TABLE 19

Yellow Perch Stomach Contents
1975-1976

	Offshore Area (#/100 Stomachs Containing Food)	Onshore Area (#/100 Stomachs Containing Food)
ASELLIDAE	1820.2	57.9
CHIRONOMIDAE	1862.5	407.9
Chironomus sp.	1428.6	316.8
Procladius sp.	423.4	90.1
Tanytarsus sp.	5.0	0
Orthocladius sp.	.5	0
Cryptochironomus sp.	.4	0
AMPHIPODA	1167.5	270.8
Gammarus sp.	1158.0	263.9
Hyalella sp.	7.3	2.0
HIRUDINEA	48.3	.5
Helobdella sp.	47.8	.5
Pisicola sp.	.5	0
OLIGOCHAETA	.6	1.4
GASTROPODA	46.2	170.8
Physa sp.	39.1	92.1
Bithnia sp.	1.2	38.1
Valvata sp.	2.6	.5
Amnicola sp.	2.1	5.0
Goniobasis sp.	0	0.5
PELYCEPODA	7.3	0
Sphaerium sp.	1.5	0
Psidium sp.	1.1	0
DECAPODA	<.1	13.4
OSTRACODA	<.1	0
PLECOPTERA	<.1	0
ODONATA	<.1	.5
EPHEMEROPTERA	<.1	.5

(CONTINUED)

TABLE 19 (CONCLUDED)

	Offshore Area (#/100 Stomachs Containing Food)	Onshore Area (#/100 Stomachs Containing Food)
HYMENOPTERA	<.1	0
HOMOPTERA	.1	0
TRICHOPTERA	.6	77.2
Hydropsychidae sp.	0	.5
Leptoceridae sp.	.1	64.4
COPEPODA	84.9	33.7
CLADOCERA	488.4	12,197.0
Daphniidae sp.	76.9	9,344.6
Bosminidae sp.	8.9	8.9
Leptodora sp.	388.2	137.6
HYDRACARINA	.2	0
OSTEICHTHYES	16.5	61.4
Osmerus sp.	10.6	41.1
Notropis sp.	.8	3.5
Alosa sp.	1.0	1.0
Dorosoma sp.	0	.5
Aplodinotus sp.	.1	1.0
Percopsis sp.	.3	1.5
All others	.3	1.5

TABLE 20

Spawning Area and Substrate Utilized by Fish Species Possibly Occurring or Known to Occur in the Ashtabula Area

Species	Spawning Area	Spawning Substrate	Primary Spawning Period
Silver Lamprey	Streams	gravel, stones	early June
Sea Lamprey	Streams	gravel, stones	early June
Lake Sturgeon	Rivers or beaches	gravel, stones	May
*Longnose Gar	Rivers or shoreline marshes	vegetation	June-July
Bowfin	Rivers or shoreline marshes	marshes in vegetation	May
*Alewife	Lake Erie shallows	sand or gravel bars	June
*Gizzardshad	Rivers and shoreline marshes	nearly any substrate	May
*Coho Salmon	Stocked		
Chinook Salmon	Stocked		
Brown Trout	Stocked		
Rainbow Trout	Stocked		
Lake Trout	Offshore or on beaches	gravel or stones	October-November
Cisco	Offshore in Western Basin		October
Whitefish	Onshore or offshore in Western Basin	gravel or sand	October
*Rainbow Smelt	Offshore or on beaches	gravel or sand	May
Mooneye	Lower rivers and protected shallows	sand or rooted aquatics	May
*Northern Pike	Streams and shoreline marshes	vegetation	Early April
Muskellunge	Streams and shoreline marshes	vegetation	Early April

* Species presence documented by the present study.

(CONTINUED)

TABLE 20 (CONTINUED)

Species	Spawning Area	Spawning Substrate	Primary Spawning Period
*Brown Bullhead	rivers and shallows	nests on sand or firm mud	June
*Yellow Bull-head	shallows or rivers or bays	firm mud and vegetation	June
*Black Bull-head	shallows of streams or shoreline	firm sand or muds	June
*Stonecat Mad-tom	nearshore or in streams	under large rocks	All summer
*Banded Killi-fish	shallow bays in quiet waters	vegetation	July
*Burbot	shallows along beaches	gravels, stones	Feb-March
*Trout-perch	nearshore areas along beaches	bedrock, sand, gravel or stones	April-June
*White Bass	lower rivers or near-shore in shallows	sand and gravel bars or vegetation	May
*White Crappie	streams, rivers, har-bors and nearshore	nearly any firm bottom substrate	May
*Black Crappie	rivers, harbors, and nearshore	among rooted aquatics or deadfall	May
*Smallmouth Blackbass	streams, rivers, onshore and offshore on reefs	firm sand, gravel or bedrock	May
*Largemouth Blackbass	streams, rivers, harbors and bays	firm sand, gravel, rock or mud	May
*Bluegill Sunfish	rivers, streams, and protected shoreline	firm sand or muds	June-July
*Green Sunfish	rivers, streams, and protected shoreline	nearly any firm substrate	June-July
*Pumpkinseed Sunfish	rivers, streams, and protected shoreline	firm bottom in vegetation	June-July
*Sauger	Stocked		
*Walleye	rivers and nearshore	reefs or gravel bars	April

* Species presence documented by the present study.

(CONTINUED)

TABLE 20 (CONTINUED)

Species	Spawning Area	Spawning Substrate	Primary Spawning Period
*Carp	shallows of Lake and rivers	nearly any substrate	May-June
*Goldfish	shallows of Lake and rivers	nearly any substrate	May-June
*Goldenshiner	shoreline marshes and rivers	vegetation	All summer
Silver Chub	offshore and on beaches	gravel bars	June
*Longnose Dace	shallows on beaches	gravel bars	June
*Emerald Shiner	offshore in open waters	pelagic eggs	June-July
*Spottail Shiner	nearshore in shallows and river mouth	sand, gravel, or vegetation	June
*Spotfin Shiner	nearshore and in rivers	eggs glued to logs, rocks, etc.	June
*Sand Shiner	nearshore and in rivers	sand, fine gravel	July
Mimic Shiner	nearshore and in rivers	sand, fine gravel	July
*Bluntnose Minnow	nearshore and in rivers	eggs glued to underside of crevices	All summer
*Quillback	nearshore and in lower rivers	sand, mud, or vegetation	April-May
Silver Redhorse	Streams	gravel	April
*Black Redhorse	Streams	gravel	May
*Golden Redhorse	Streams	gravel	May
*Northern Redhorse	Streams	gravel	May
*White Sucker	nearshore and in rivers	gravel or stones	April
*Channel Catfish	nearshore and in rivers	logjams or rocks in crevices	late June

* Species presence documented by the present study.

(CONTINUED)

TABLE 20 (CONCLUDED)

Species	Spawning Area	Spawning Substrate	Primary Spawning Period
*Yellow Perch	rivers, bays, nearshore, or offshore	vegetation, detritus or on firm bottoms	April-May
*Logperch Darter	nearshore or offshore	gravel	June
*Scaley Johnny Darter	nearshore	underside of rocks	May-June
*Freshwater Drum	rivers, nearshore, or offshore	pelagic eggs	June-August
*Northern Mottled Sculpin	nearshore or offshore	under rocks	May

* Species presence documented by the present study.

Table 21

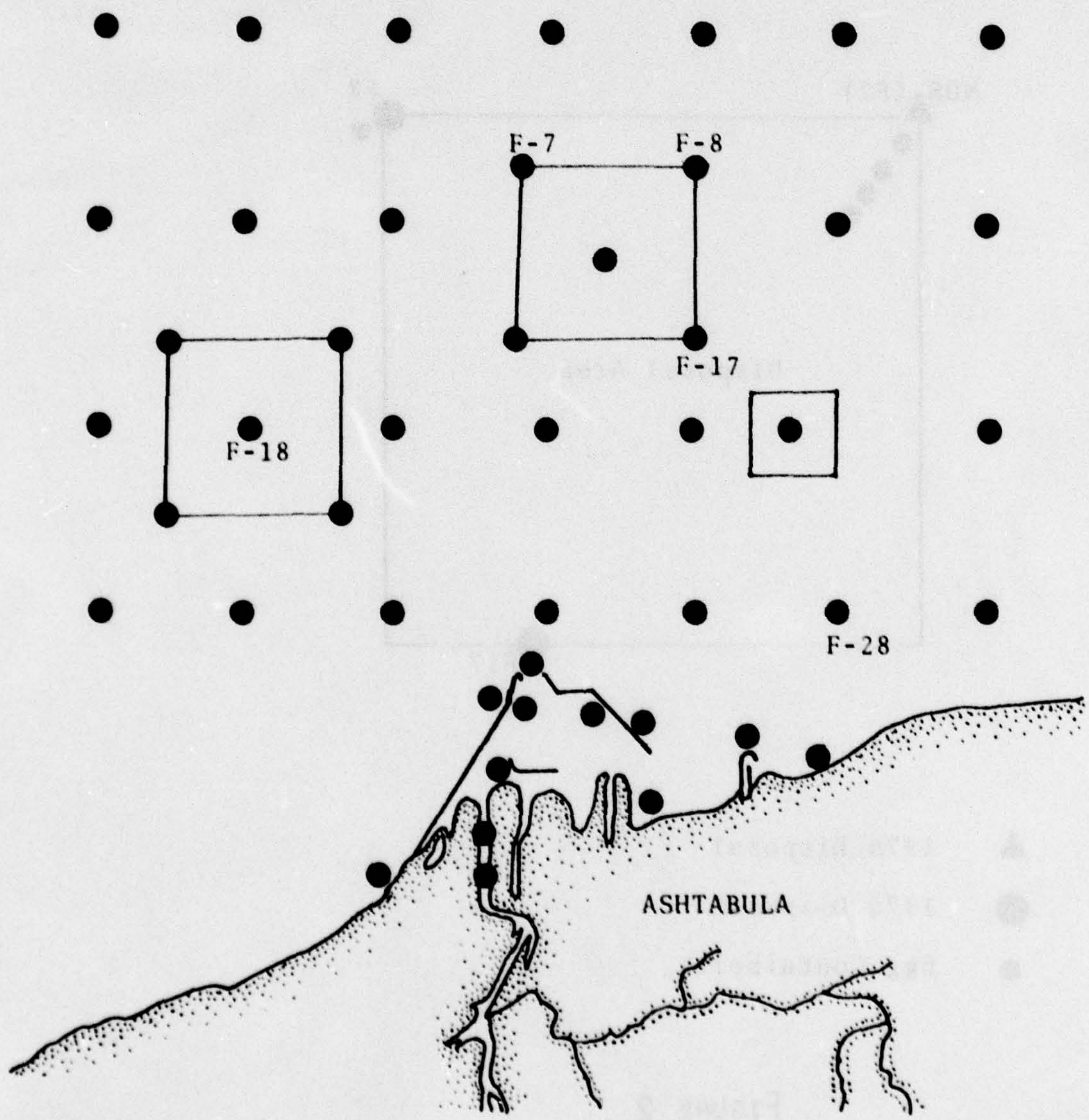
Monthly Abundance* of Bottom-Inhabiting Nekton in Nearshore and Offshore Areas

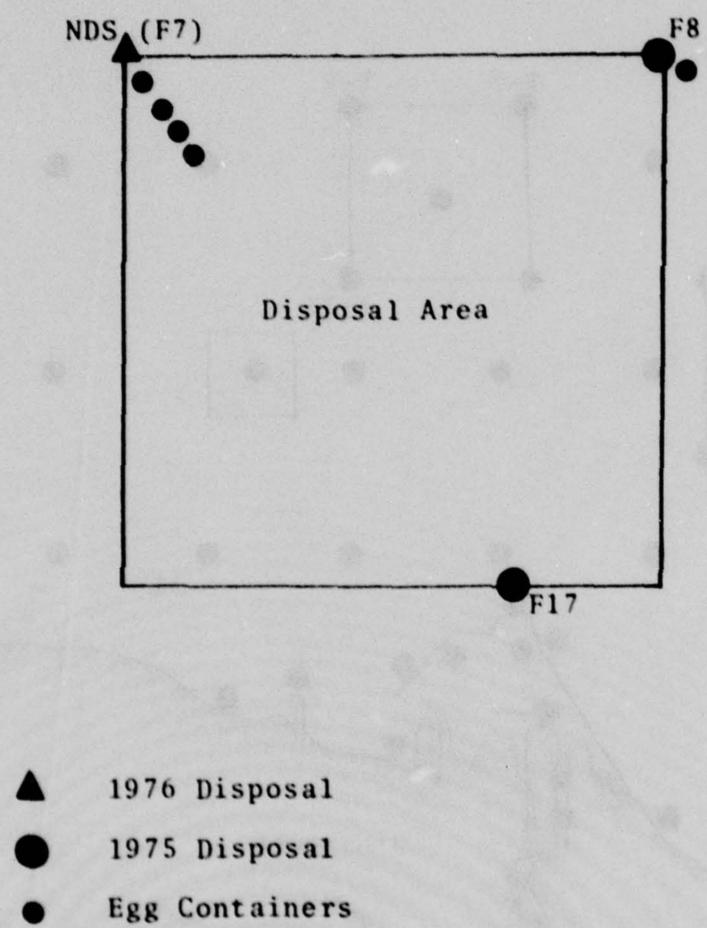
	Offshore Area		Nearshore Area	
Month	All Species	Yellow Perch	All Species	Yellow Perch
March	14.83	8.87	-	-
April	70.91	63.87	24.44	6.67
May	112.08	89.44	364.66	281.07
June	110.42	107.51	322.32	233.89
July	185.51	169.60	103.94	29.58
August	1.54	1.02	172.11	128.16

* Expressed in fish per 1000 ft of net per 24 hr.

FIGURE 1

Preliminary Survey Sites - July 1975



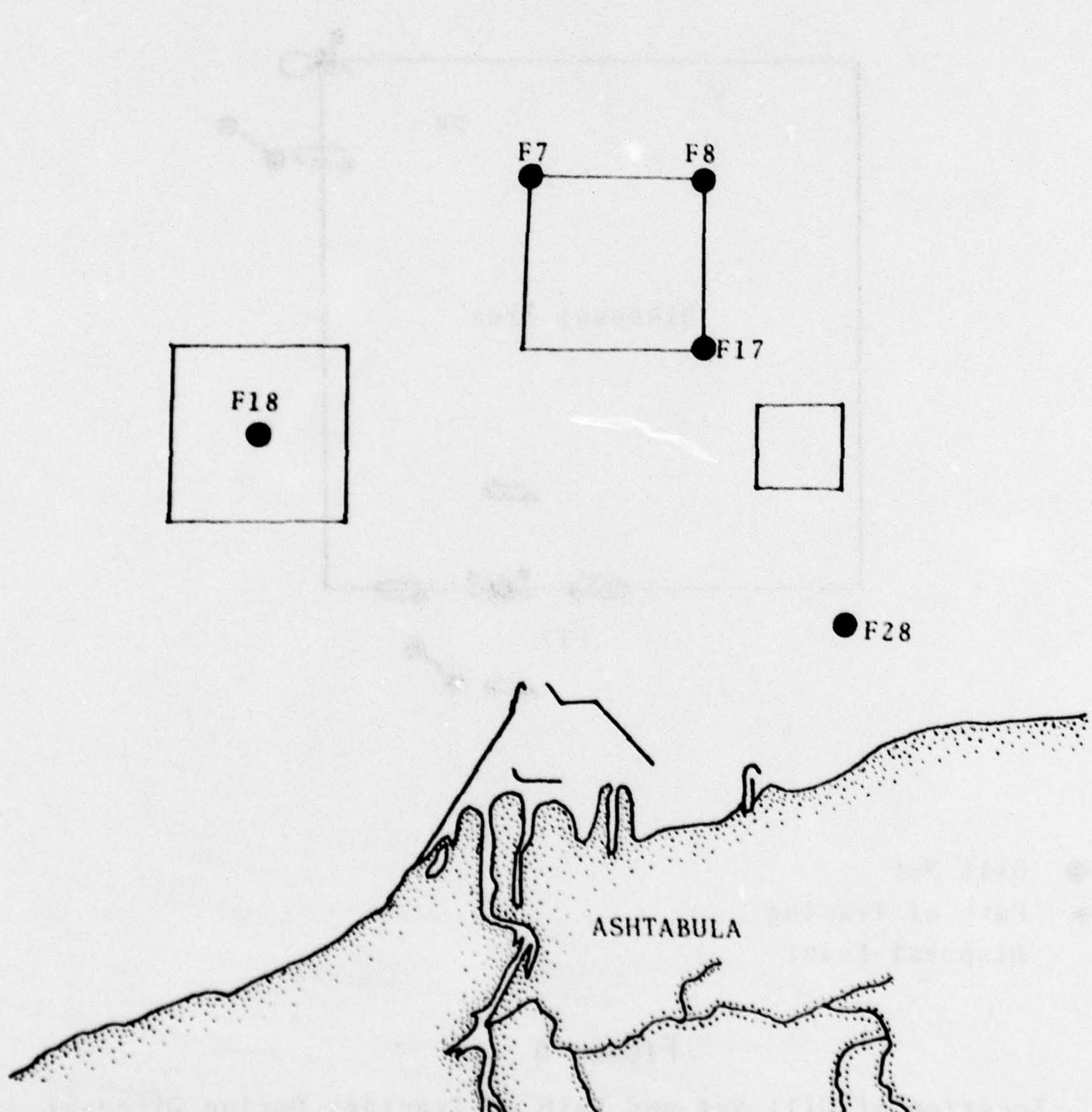


[illegible]RE 2

Location of Exp[illegible]ntal Egg Containers in the Disposal Area - 1976

FIGURE 3

Intensive Study Sites - 1975-76



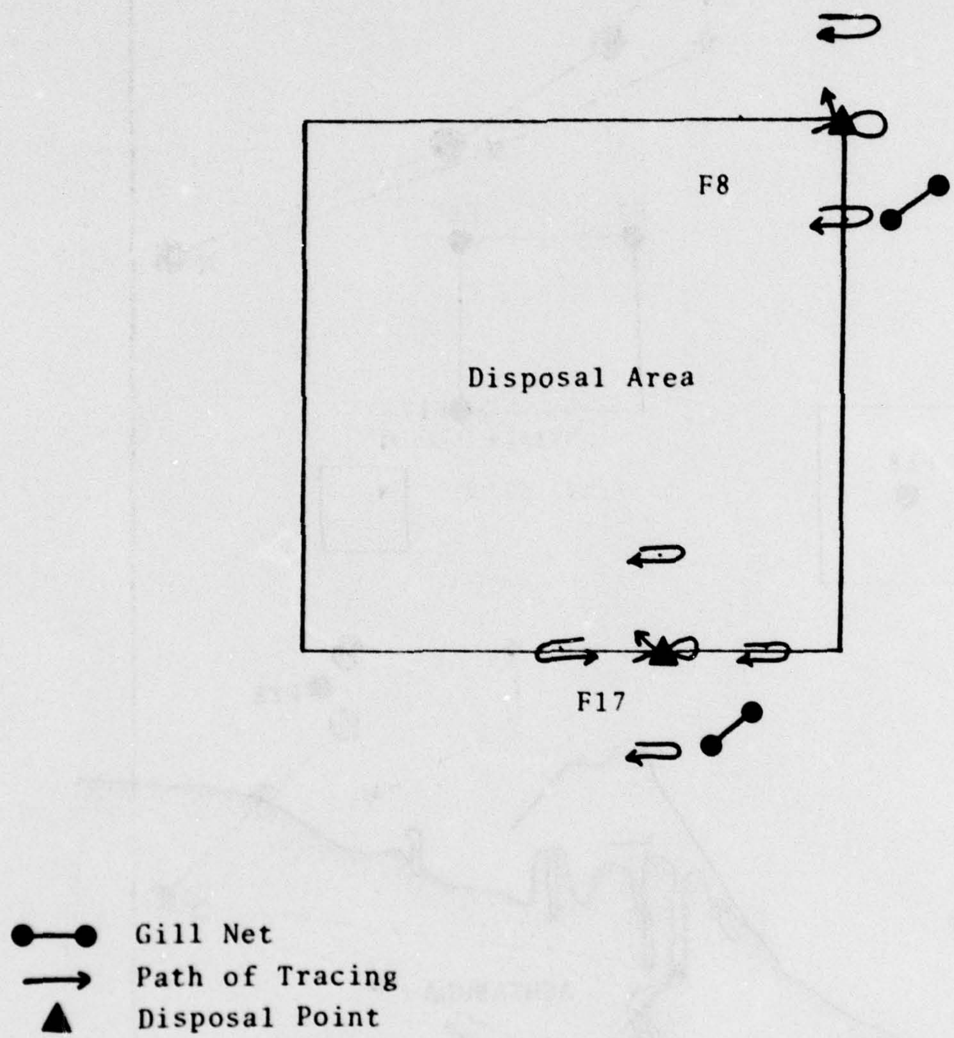
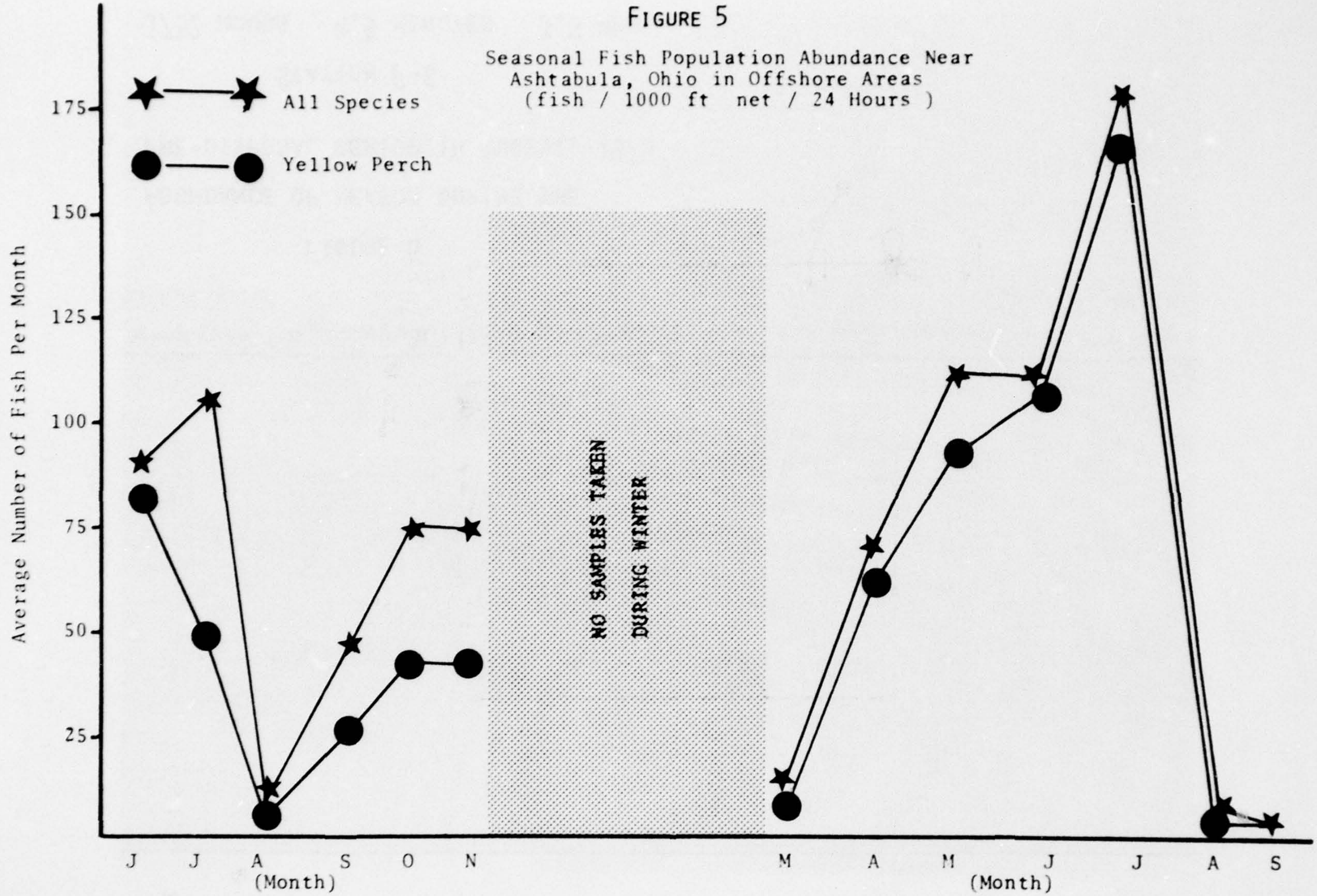


FIGURE 4

Location of Gill Net and Path of Tracings During Disposal at stations D-2 and D-8 in 1975

FIGURE 5

Seasonal Fish Population Abundance Near Ashtabula, Ohio in Offshore Areas (fish / 1000 ft net / 24 Hours)



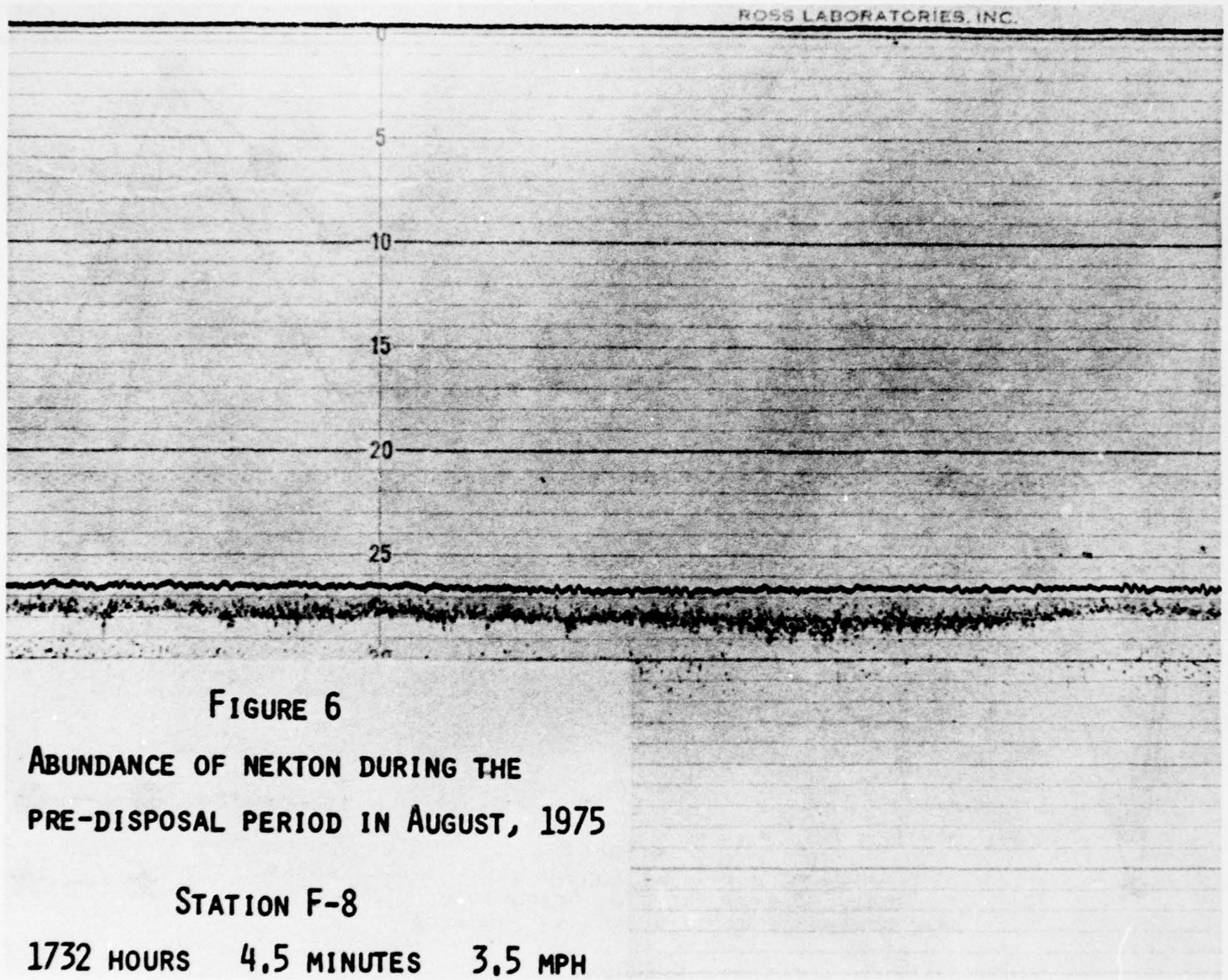


FIGURE 6

ABUNDANCE OF NEKTON DURING THE PRE-DISPOSAL PERIOD IN AUGUST, 1975

STATION F-8

1732 HOURS 4.5 MINUTES 3.5 MPH

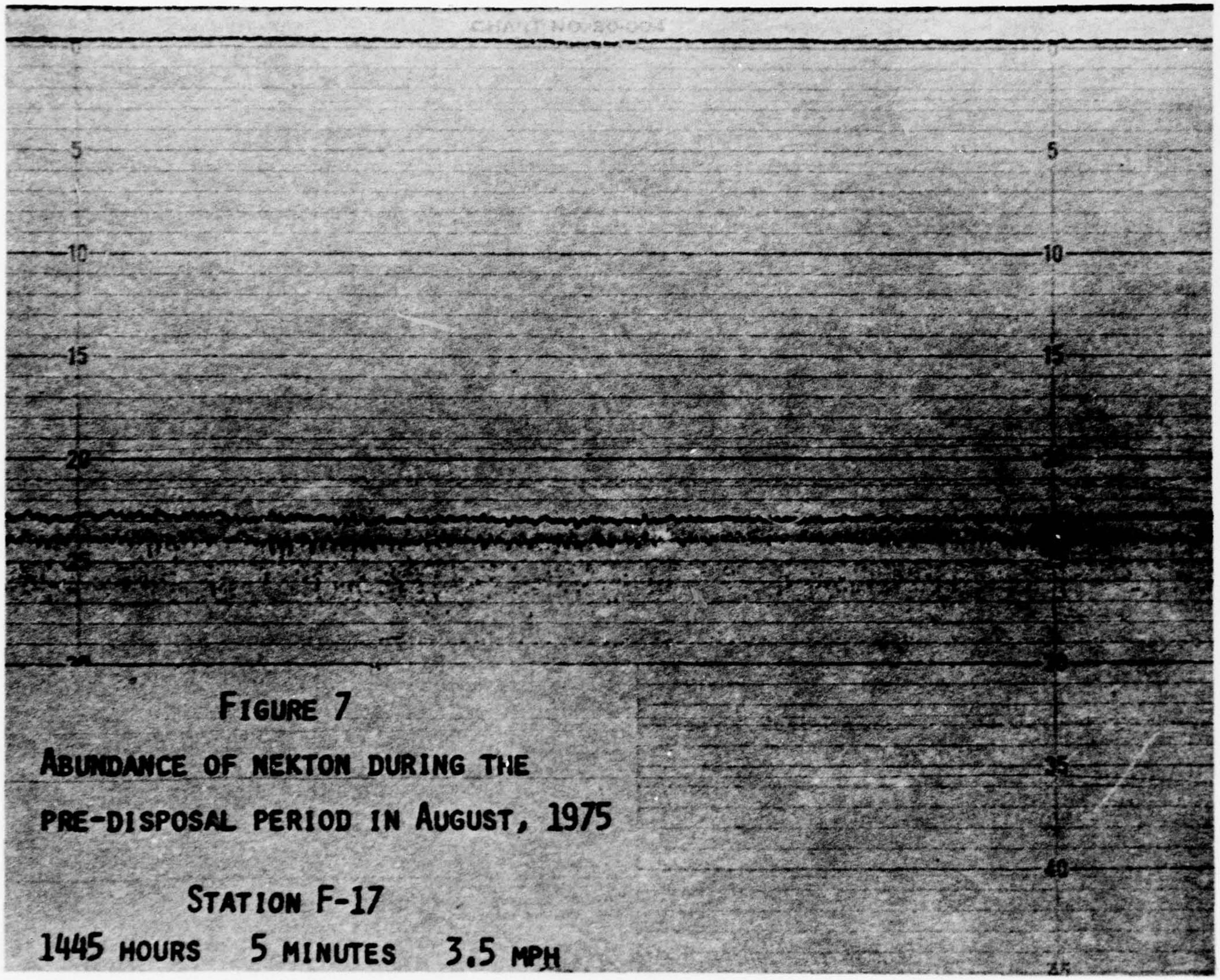


FIGURE 7

ABUNDANCE OF NEKTON DURING THE PRE-DISPOSAL PERIOD IN AUGUST, 1975

STATION F-17

1445 HOURS 5 MINUTES 3.5 MPH

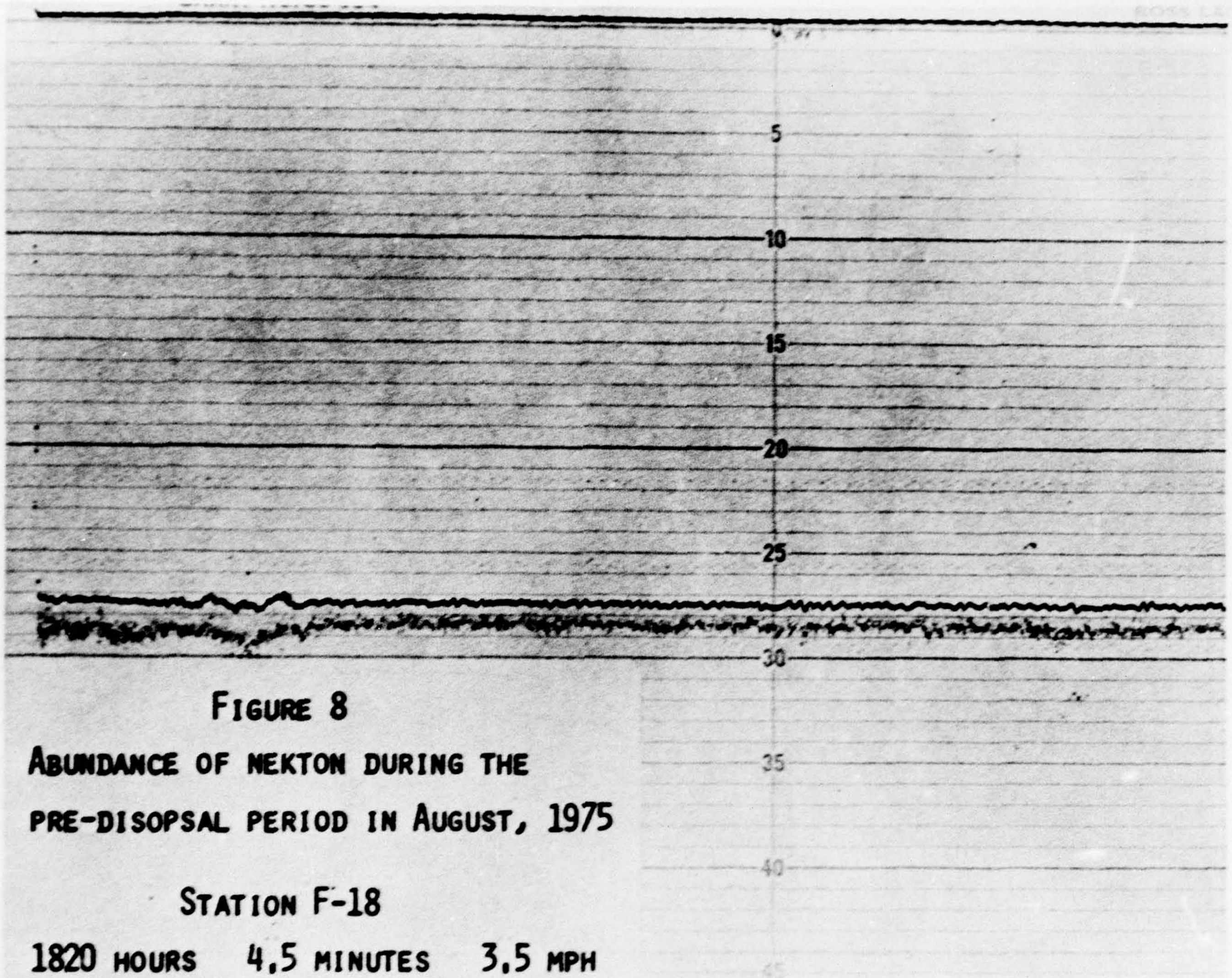


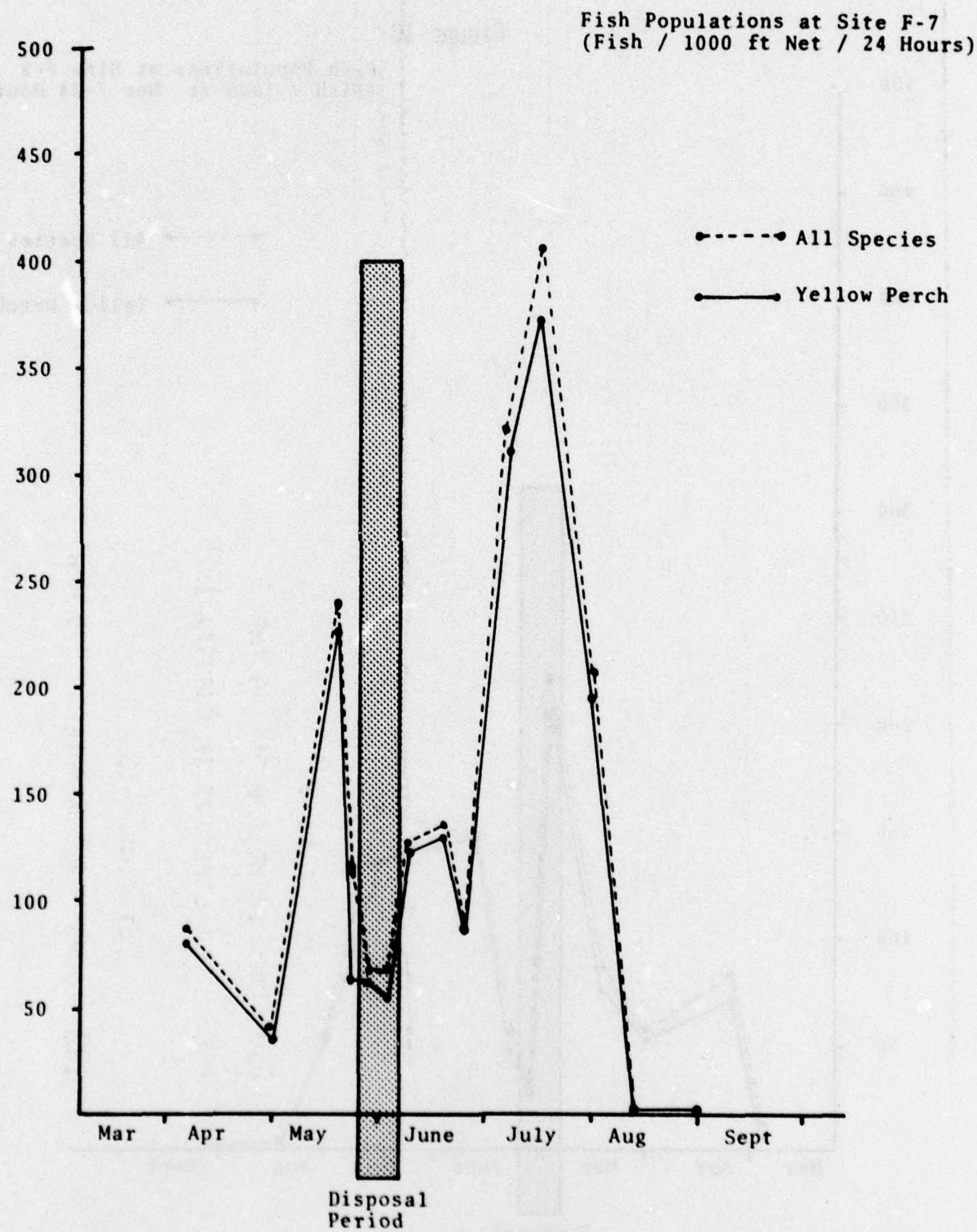
Figure 8

Abundance of nekton during the pre-disopsal period in August, 1975

Station F-18

1820 hours 4.5 minutes 3.5 mph

FIGURE 9



Fish Populations at Site F-7
(Fish / 1000 ft Net / 24 Hours)
500
450
400
350
300
250
200
150
100
50
All Species
Yellow Perch
Mar
Apr
May
June
July
Aug
Sept
Disposal
Period

FIGURE 10

Fish Populations at Site F-8
(Fish / 1000 ft Net / 24 Hours)

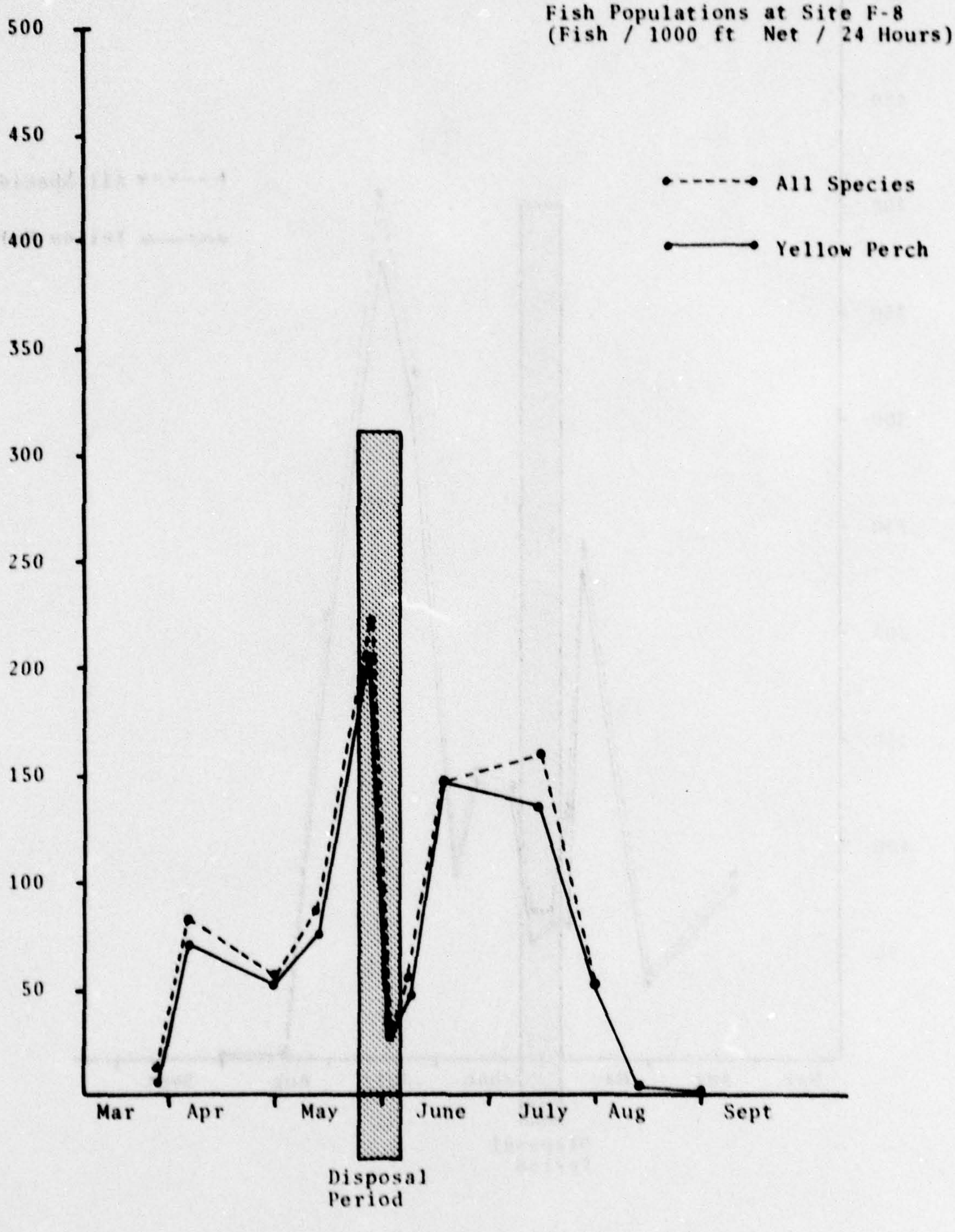
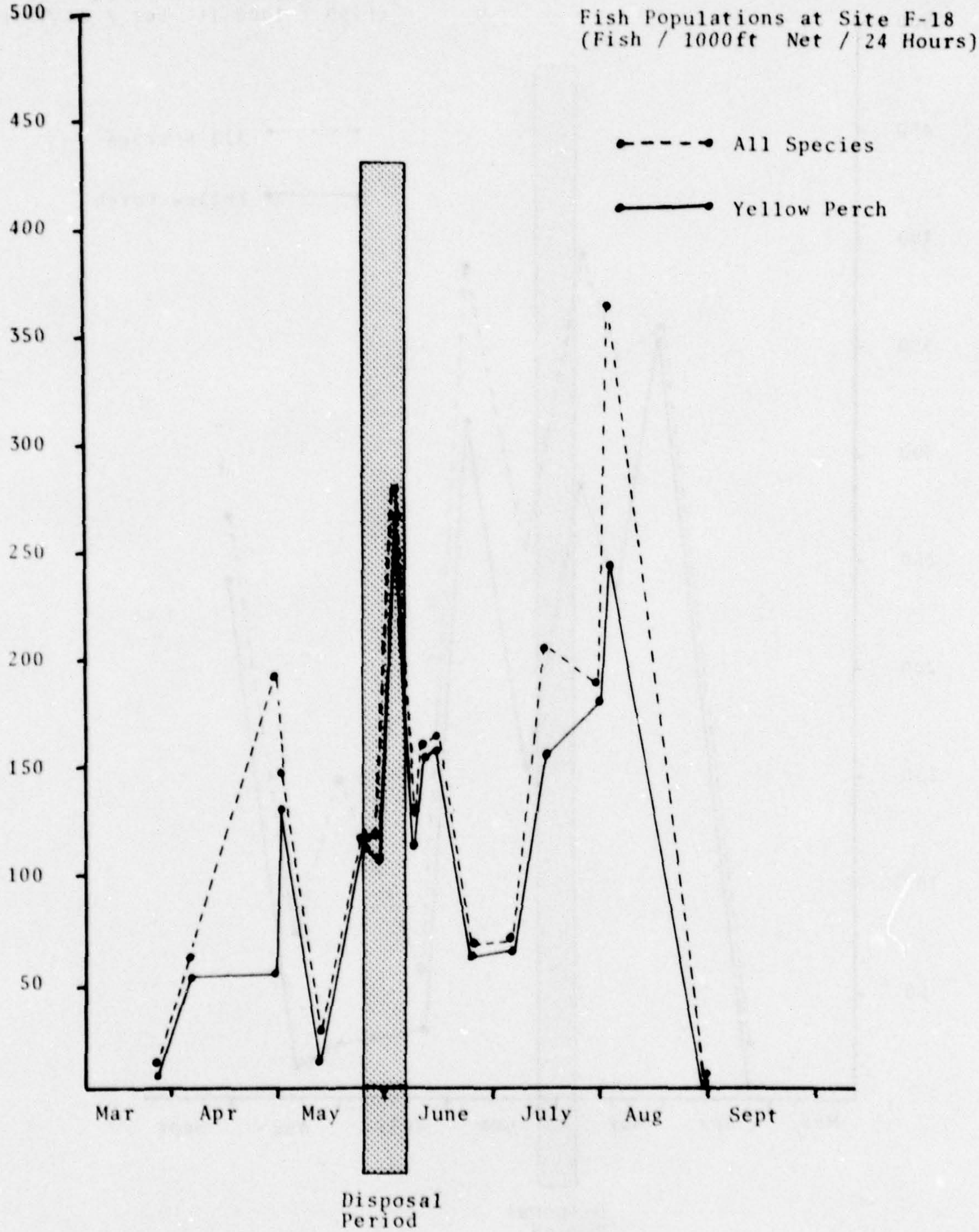


FIGURE 11



Fish Populations at Site F-18
(Fish / 1000ft Net / 24 Hours)
All Species
Yellow Perch
500
450
400
350
300
250
200
150
100
50
Mar
Apr
May
June
July
Aug
Sept
Disposal
Period

FIGURE 12

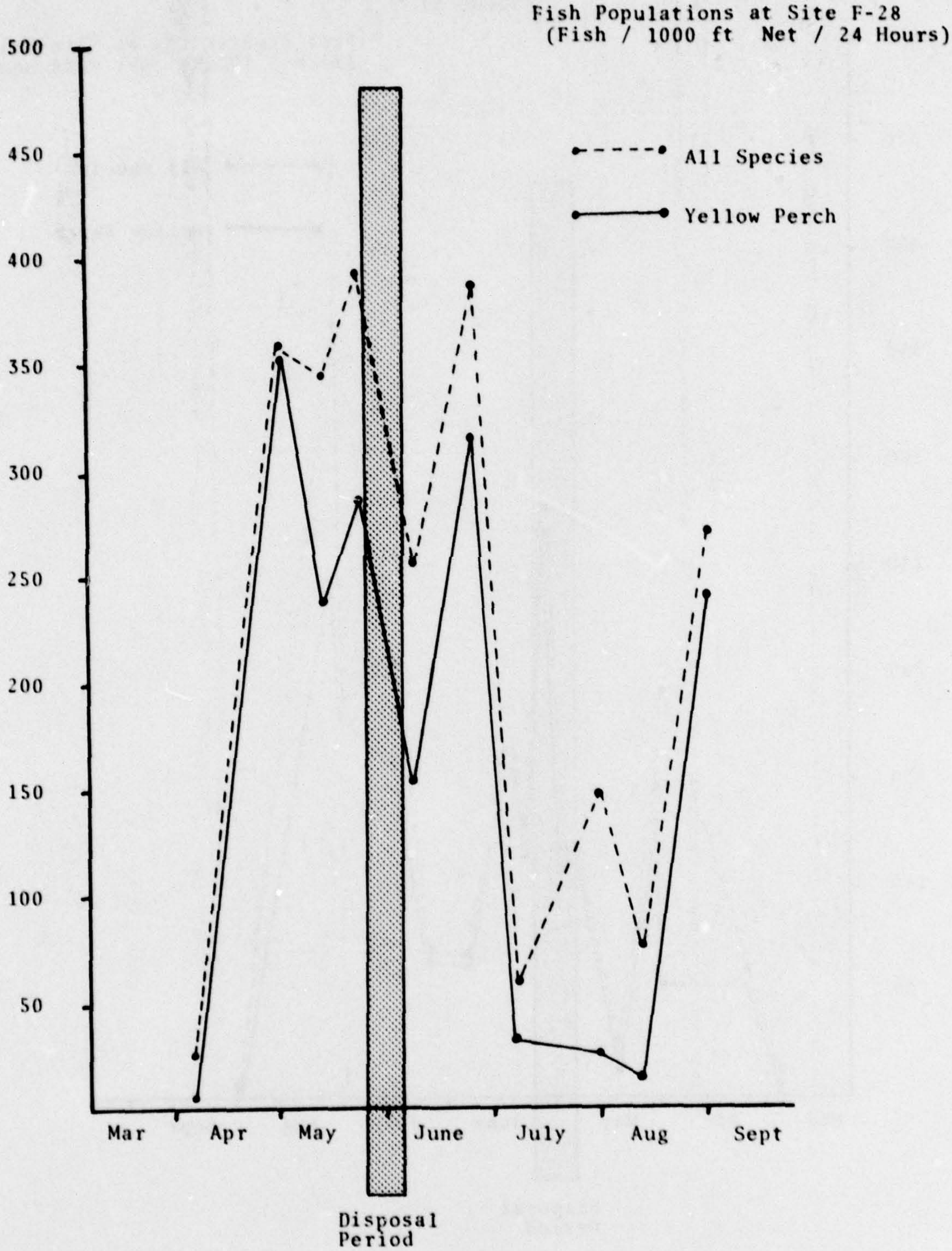
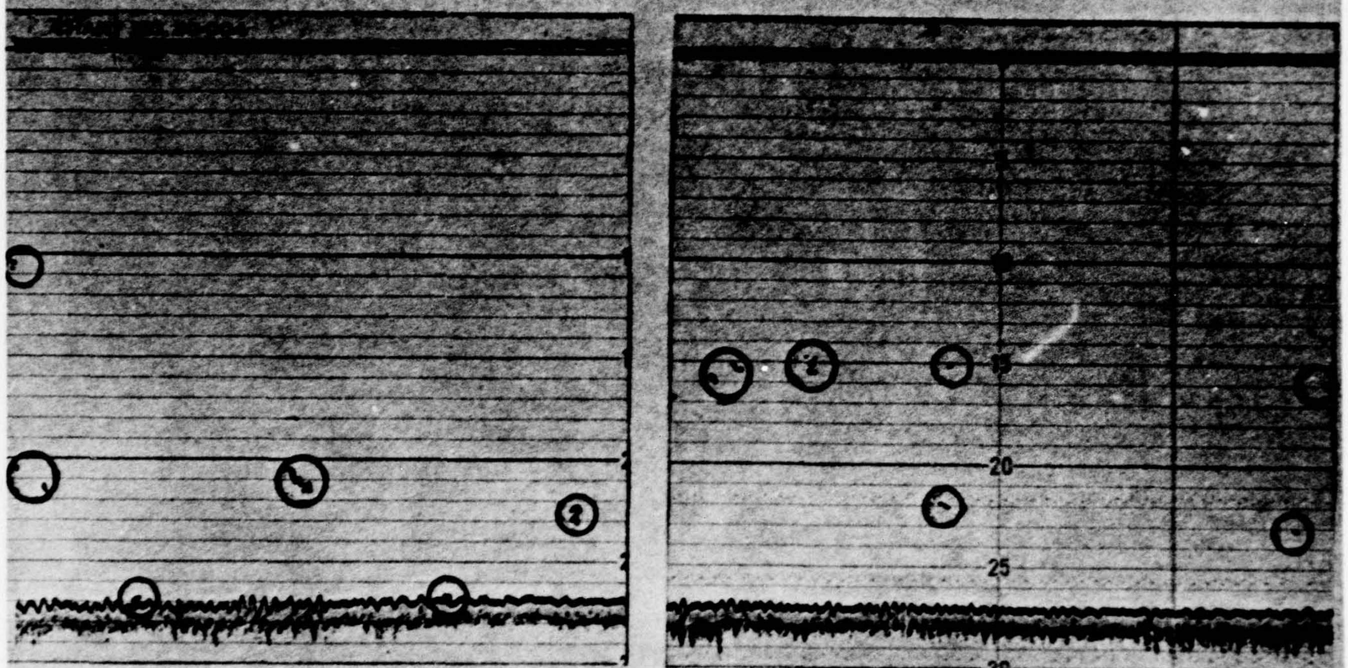

Fish Populations at Site F-28
(Fish / 1000 ft Net / 24 Hours)
All Species
Yellow Perch
500
450
400
350
300
250
200
150
100
50
Mar
Apr
May
June
July
Aug
Sept
Disposal
Period

FIGURE 13

PRE-DISPOSAL FISH CONCENTRATIONS AT STATIONS D-2 AND D-4

5 AUGUST 1975



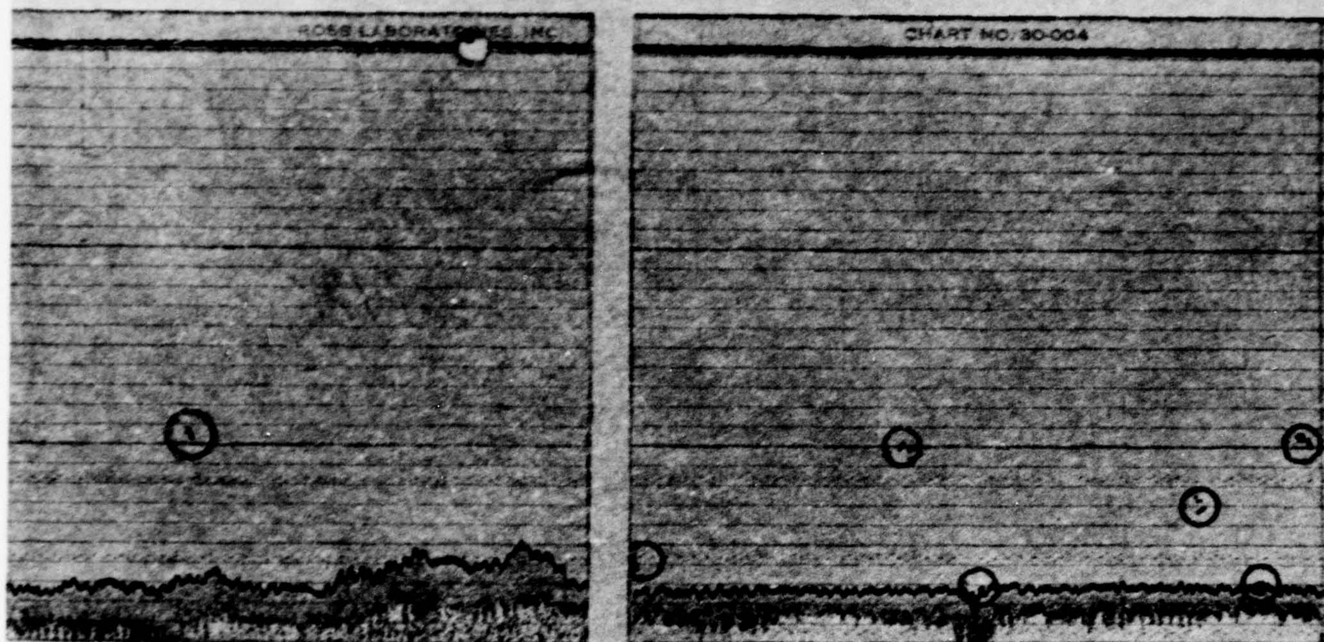
STATION D-2

STATION D-4

Figure 14

Fish concentrations after disposal at station D-2 on 5 August

10 minutes post-disposal - stations D-2 and D-4

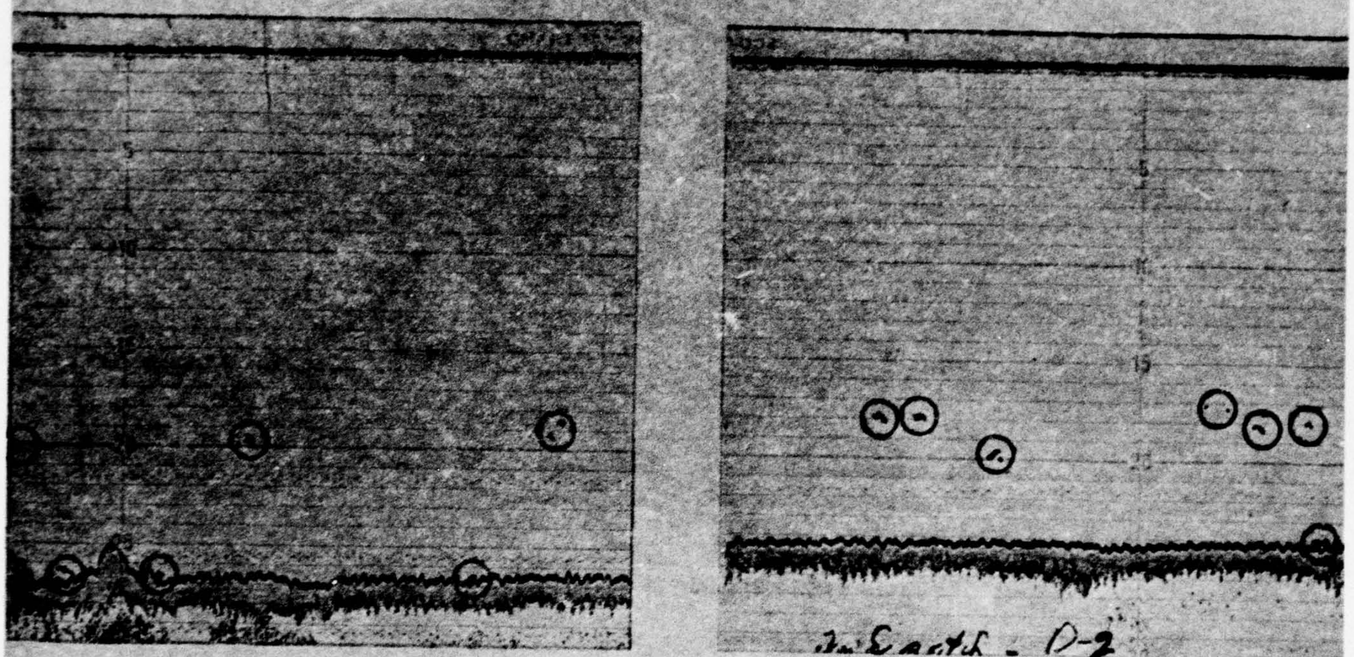


Station D-2

Station D-4

FIGURE 15

FISH CONCENTRATIONS AFTER DISPOSAL AT STATION D-2 ON 5 AUGUST
30 MINUTES POST-DISPOSAL - STATIONS D-2 AND D-4.



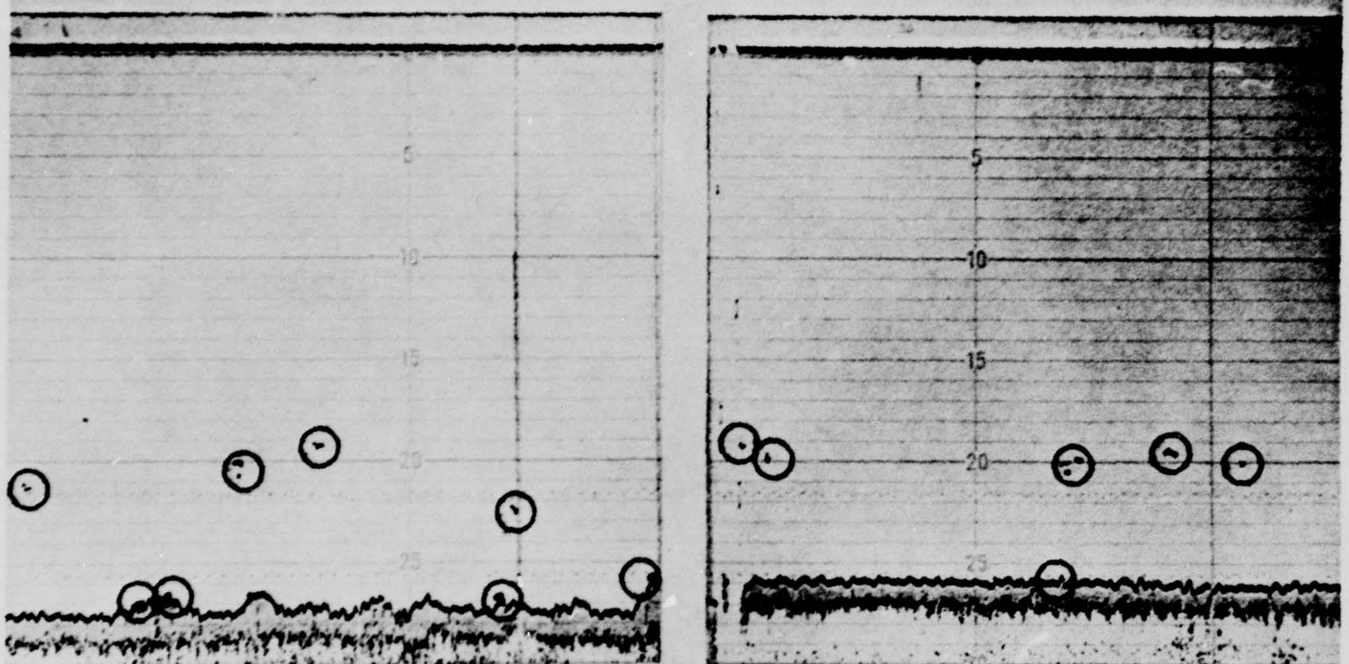
STATION D-2

STATION D-4

FIGURE 16

FISH CONCENTRATIONS AFTER DISPOSAL AT STATION D-2 ON 5 AUGUST

90 MINUTES POST-DISPOSAL - STATIONS D-2 AND D-4



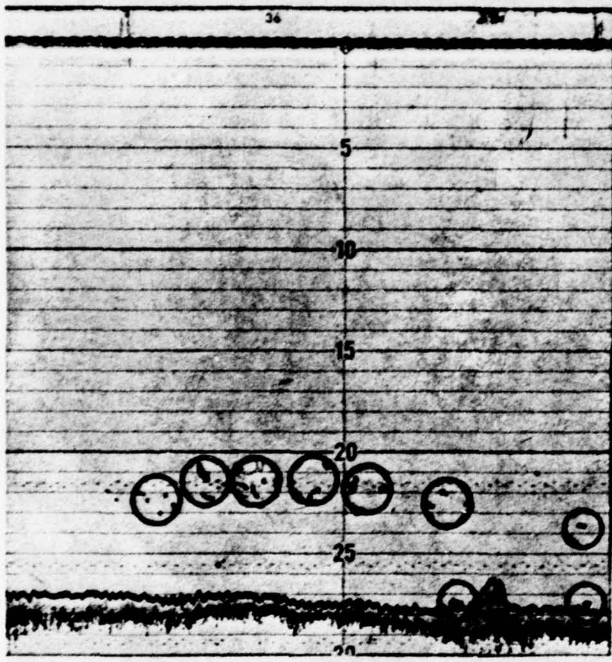
STATION D-2

STATION D-4

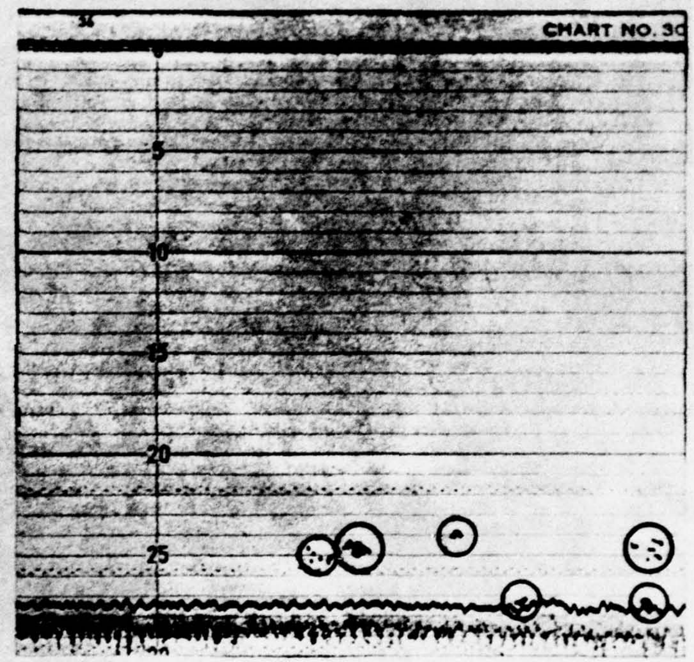
Figure 17

Fish concentrations after disposal at station D-2 on 5 August

180 minutes post-disposal - stations D-2 and D-4



Station D-2



Station D-4

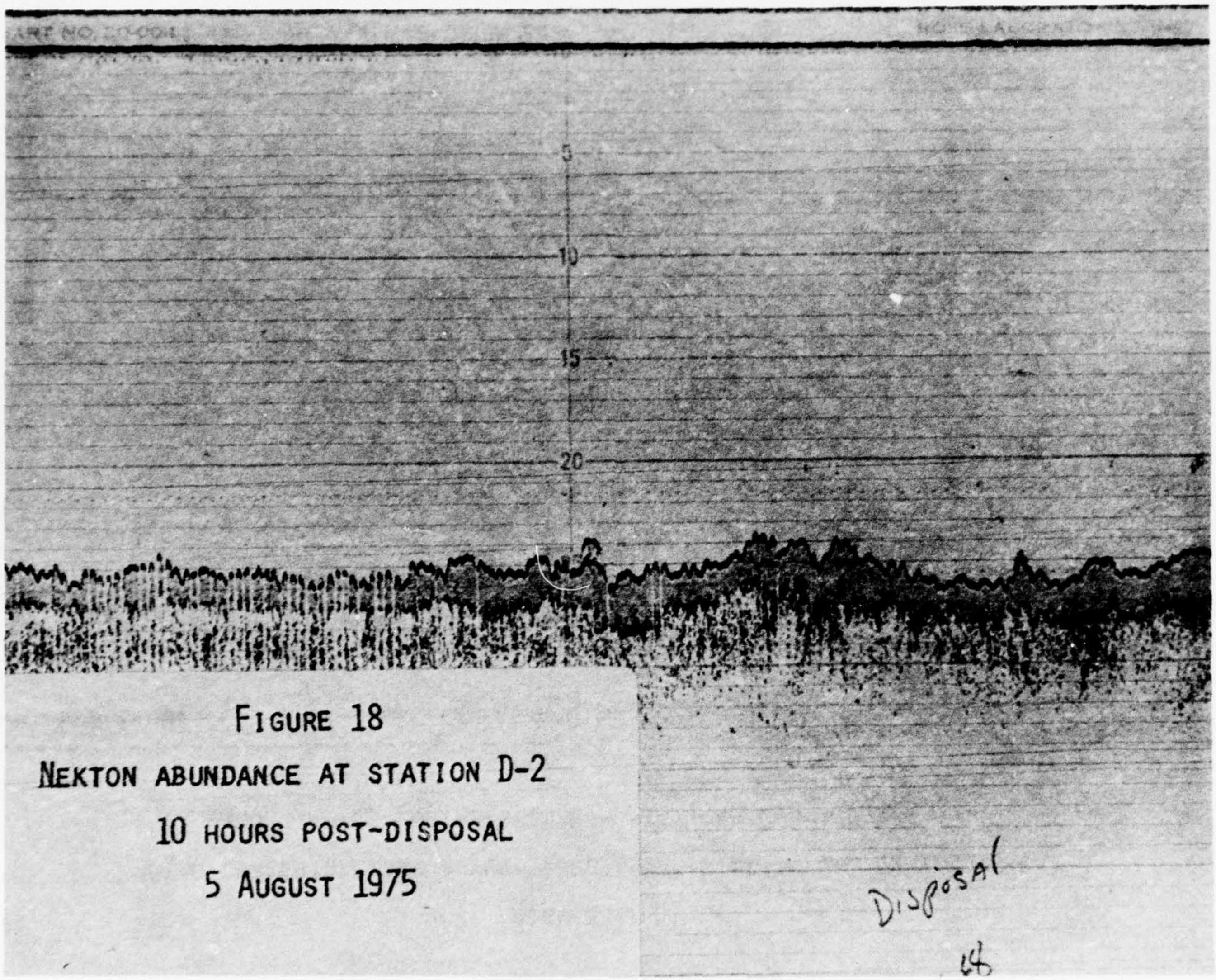


FIGURE 18

NEKTON ABUNDANCE AT STATION D-2

10 HOURS POST-DISPOSAL

5 AUGUST 1975

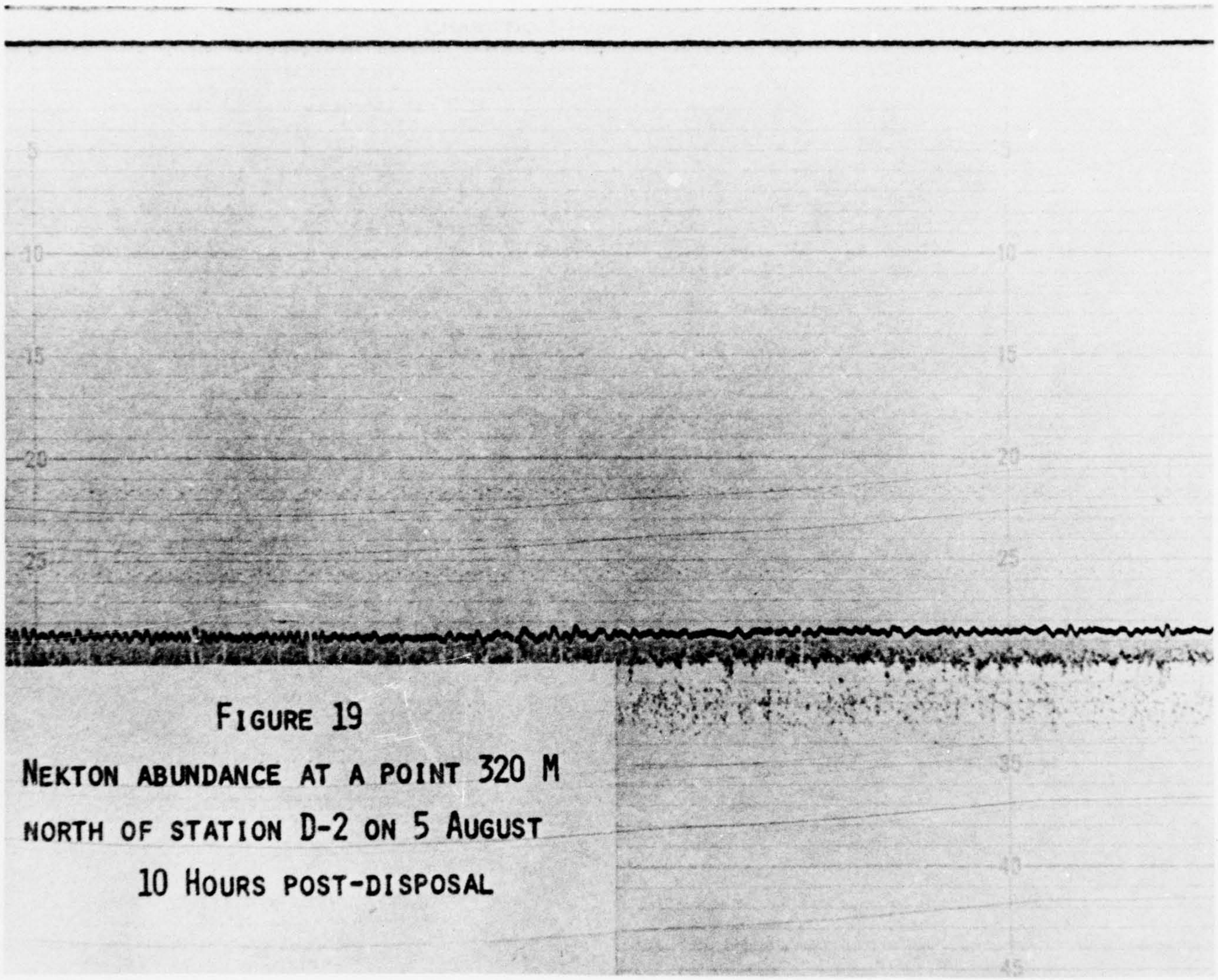


FIGURE 19

NEKTON ABUNDANCE AT A POINT 320 M NORTH OF STATION D-2 ON 5 AUGUST

10 HOURS POST-DISPOSAL

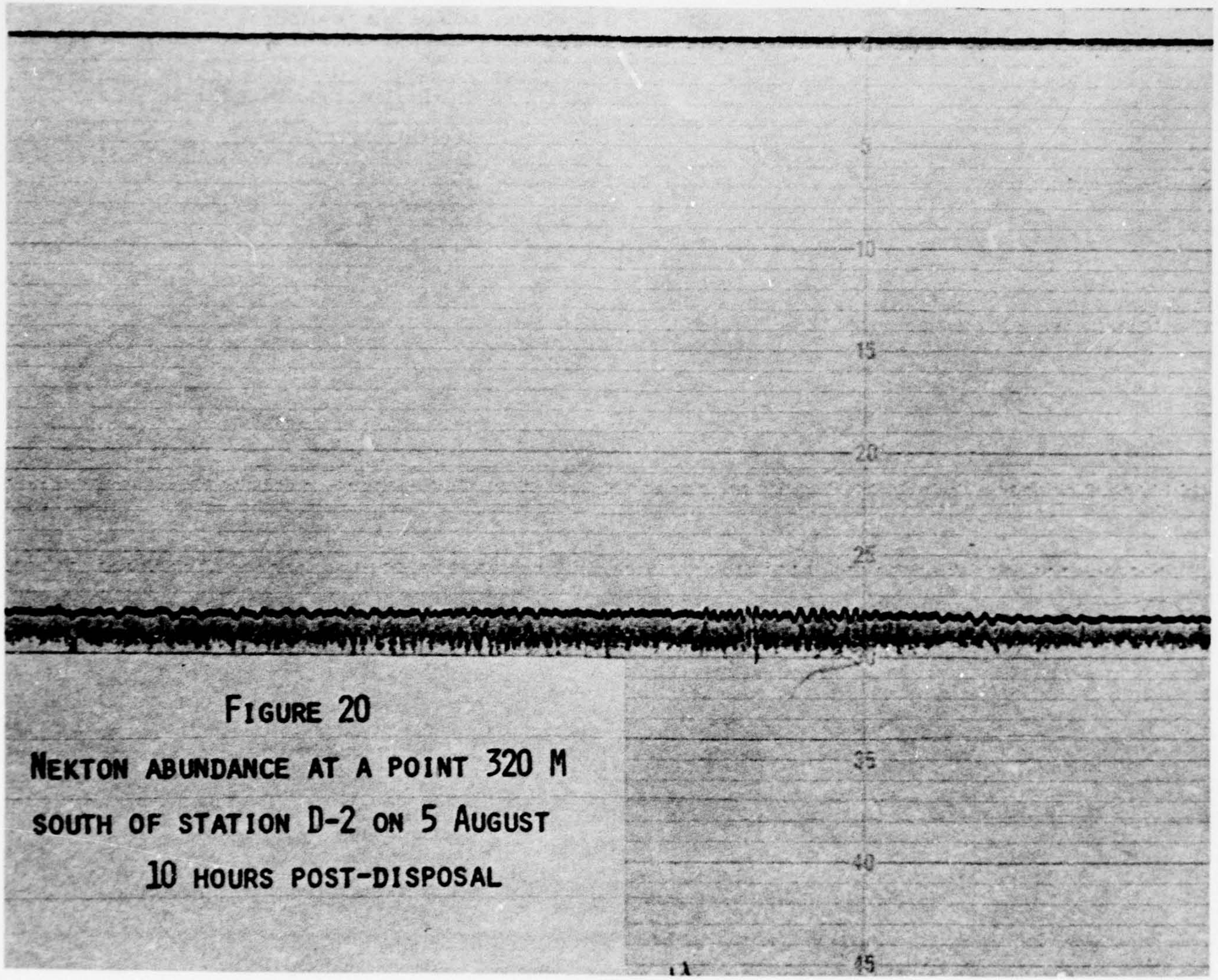


FIGURE 20

NEKTON ABUNDANCE AT A POINT 320 M SOUTH OF STATION D-2 ON 5 AUGUST 10 HOURS POST-DISPOSAL

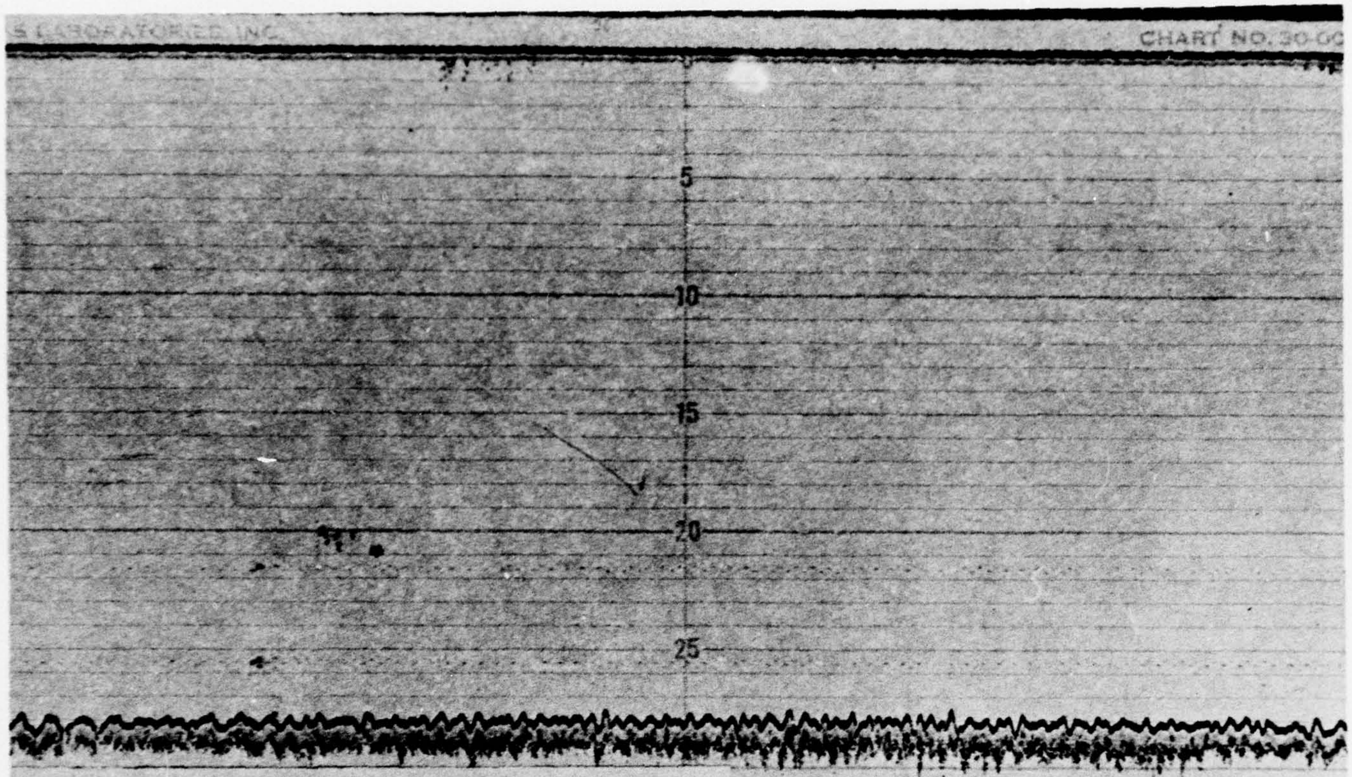


FIGURE 21

NEKTON ABUNDANCE AT A POINT 320 M
EAST OF STATION D-2 ON 5 AUGUST
10 HOURS POST-DISPOSAL

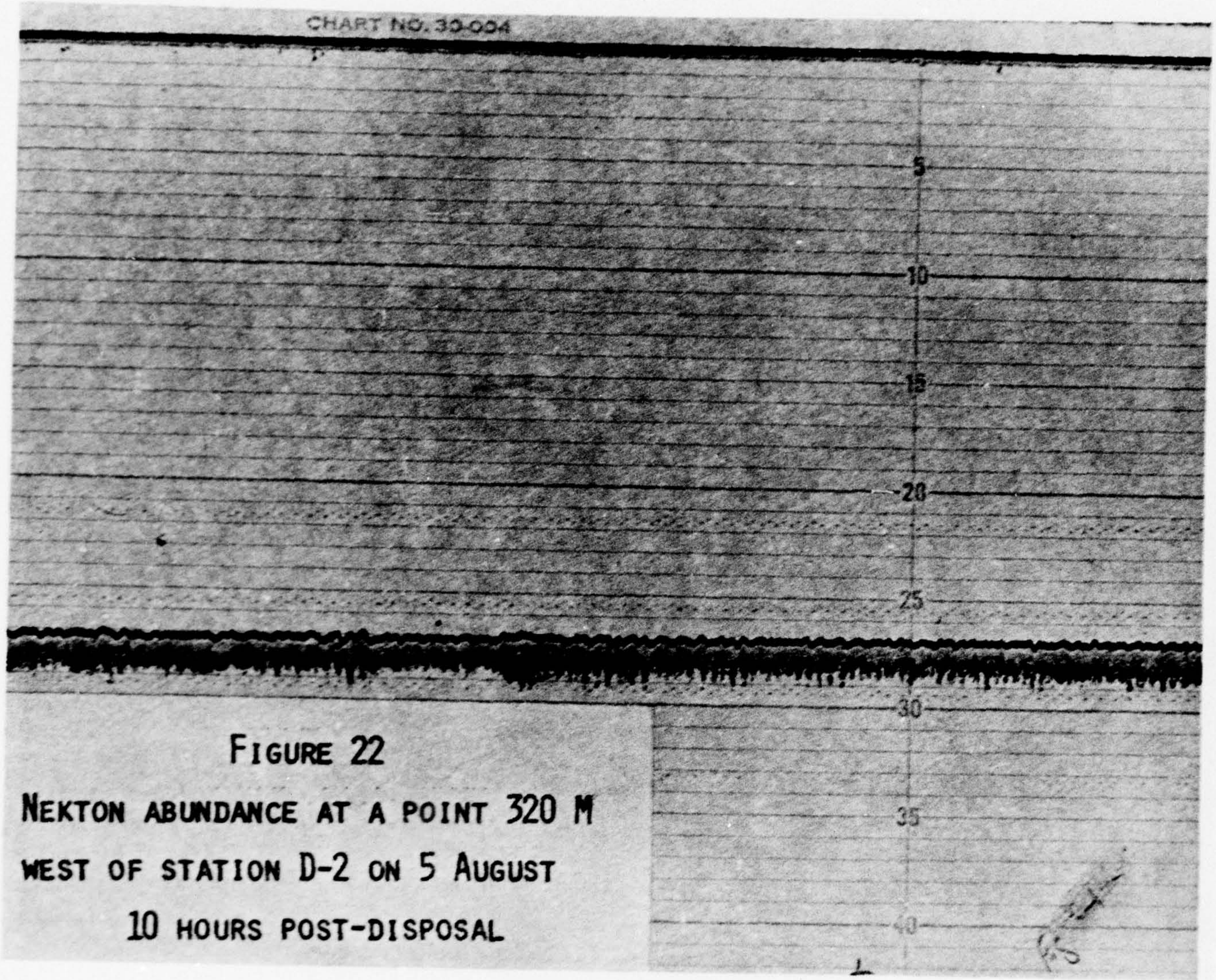


FIGURE 22

NEKTON ABUNDANCE AT A POINT 320 M WEST OF STATION D-2 ON 5 AUGUST 10 HOURS POST-DISPOSAL

Figure 23

Fish located adjacent to plume from disposal event

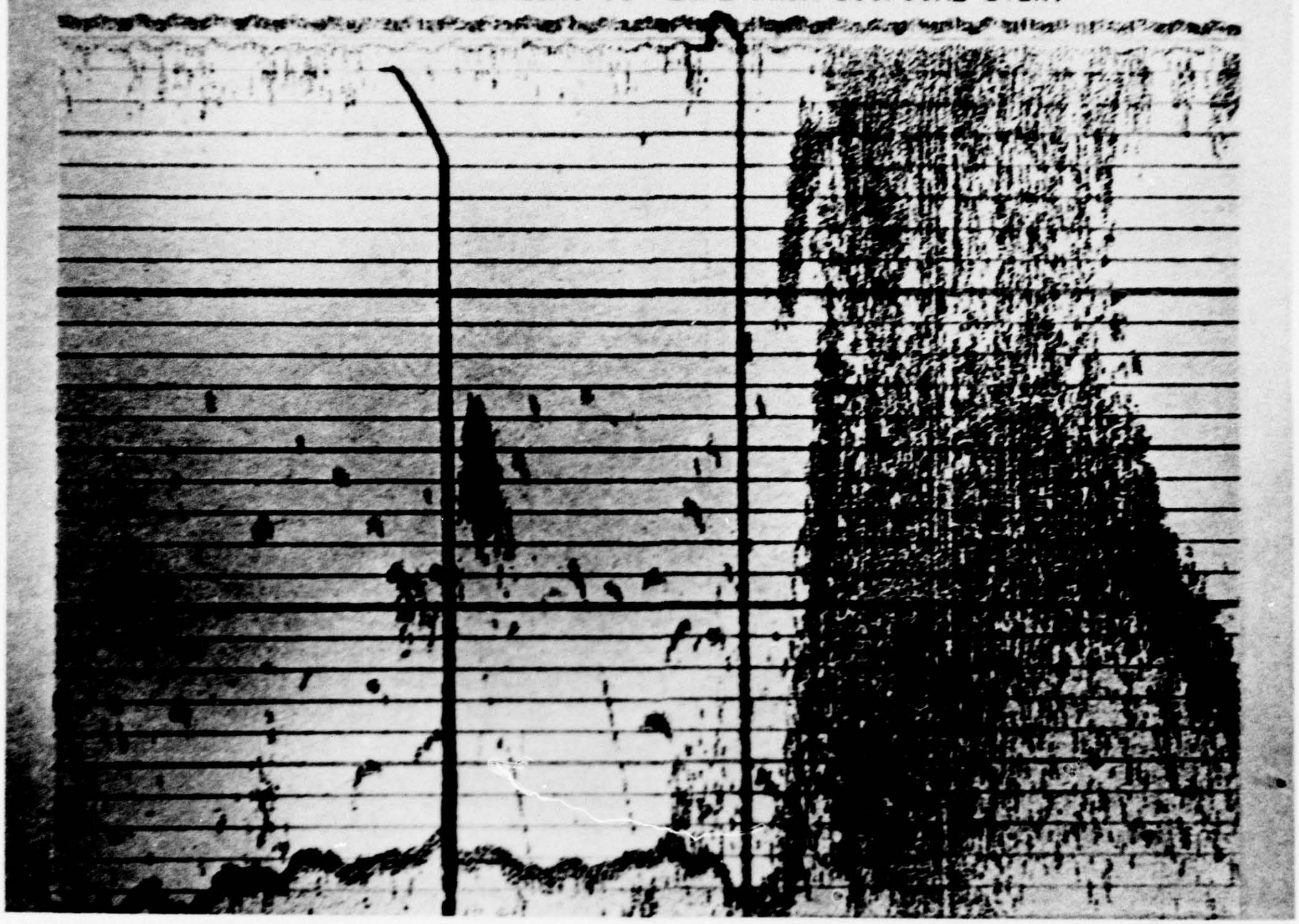


FIGURE 24

MIDWATER INDIVIDUALS OF NEKTON ON DISPOSAL PLUME EDGE

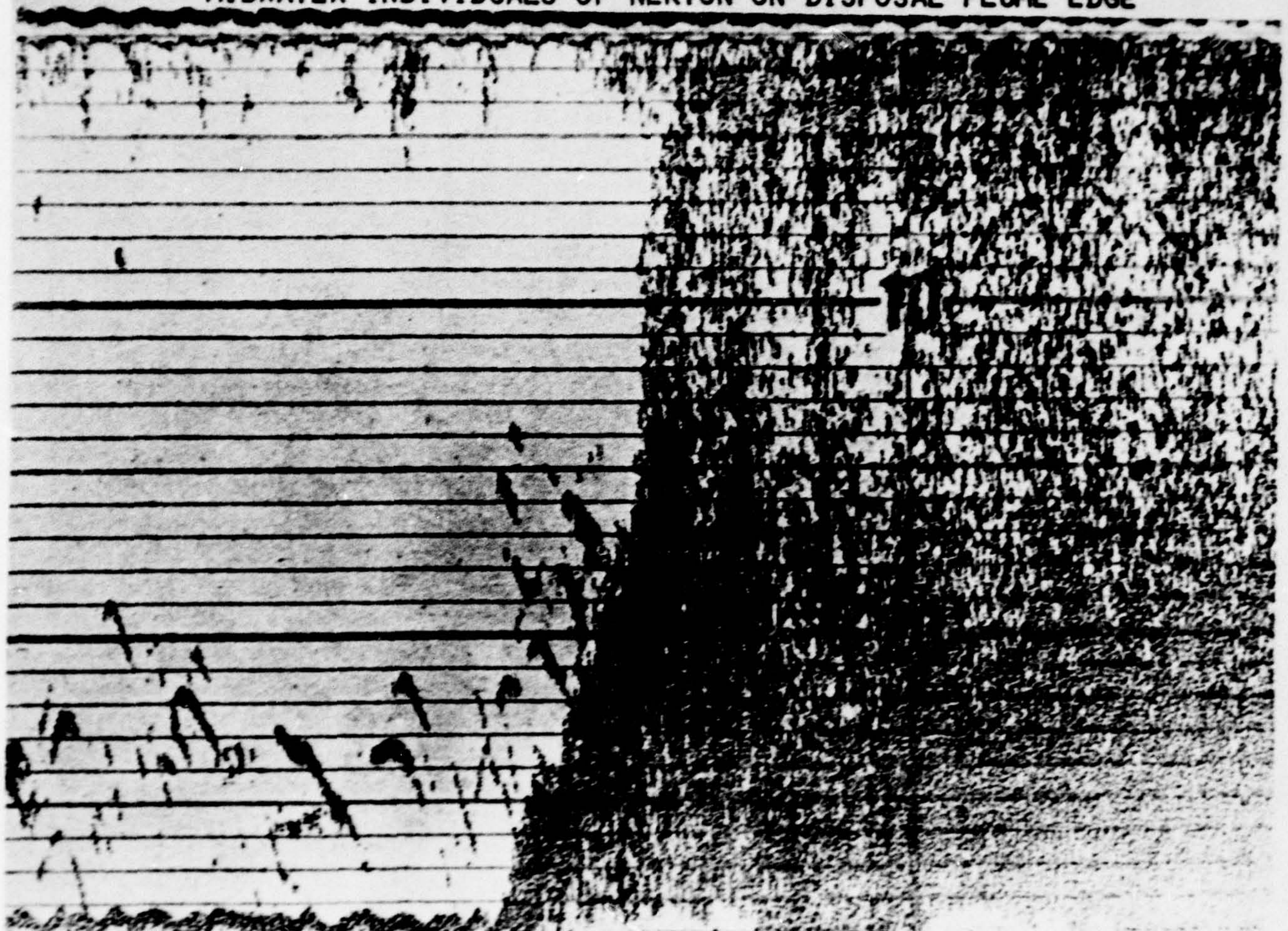


FIGURE 25

FISH INDIVIDUALS INSIDE PLUME IN "OPEN" AREAS

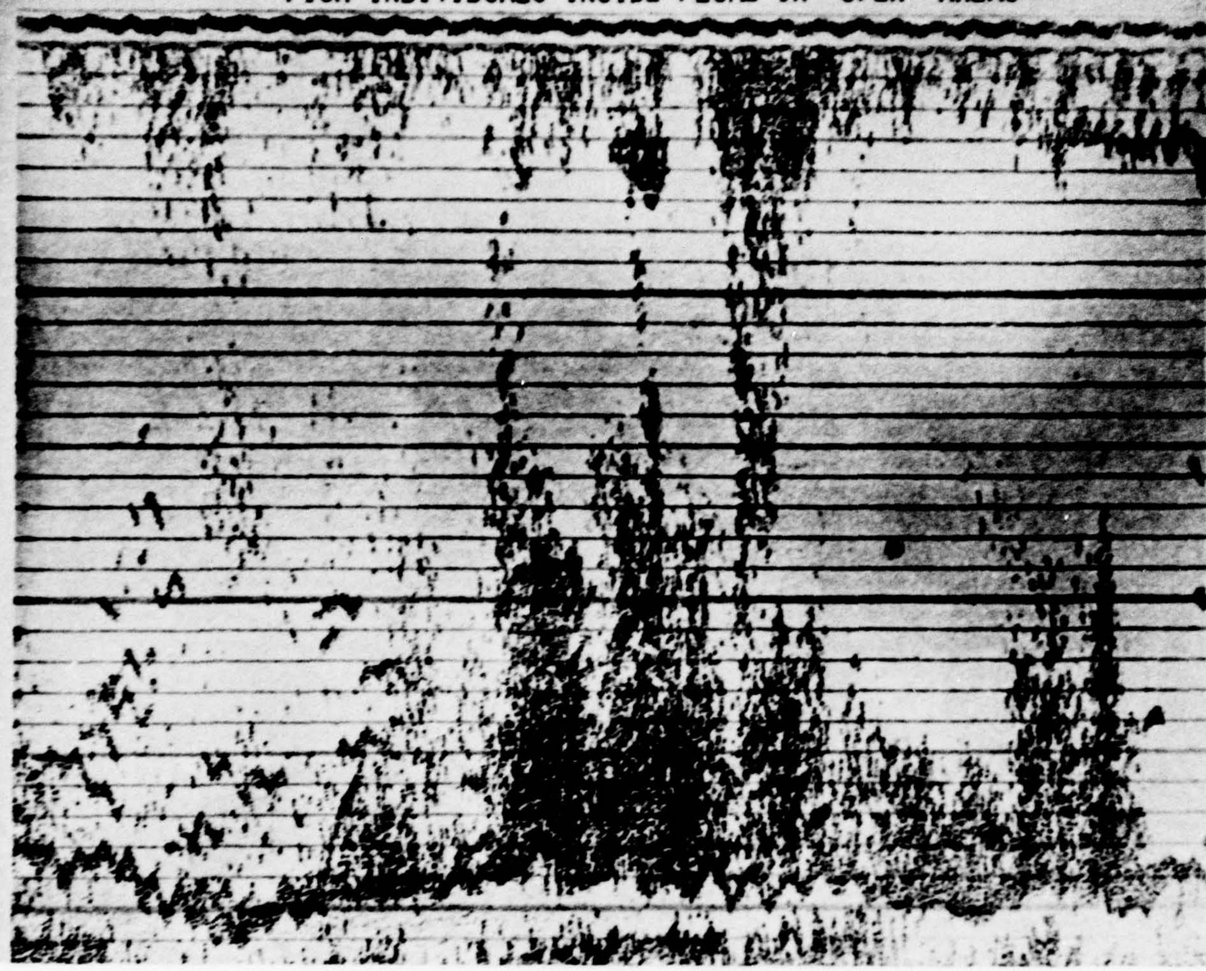


Figure 26

Fish response to disposal plume after approximately 1 minute

Figure 27

Fish response to disposal plume after approximately 2 minutes

FIGURE 28

FISH RESPONSE TO DISPOSAL PLUME AFTER APPROXIMATELY 10 MINUTES

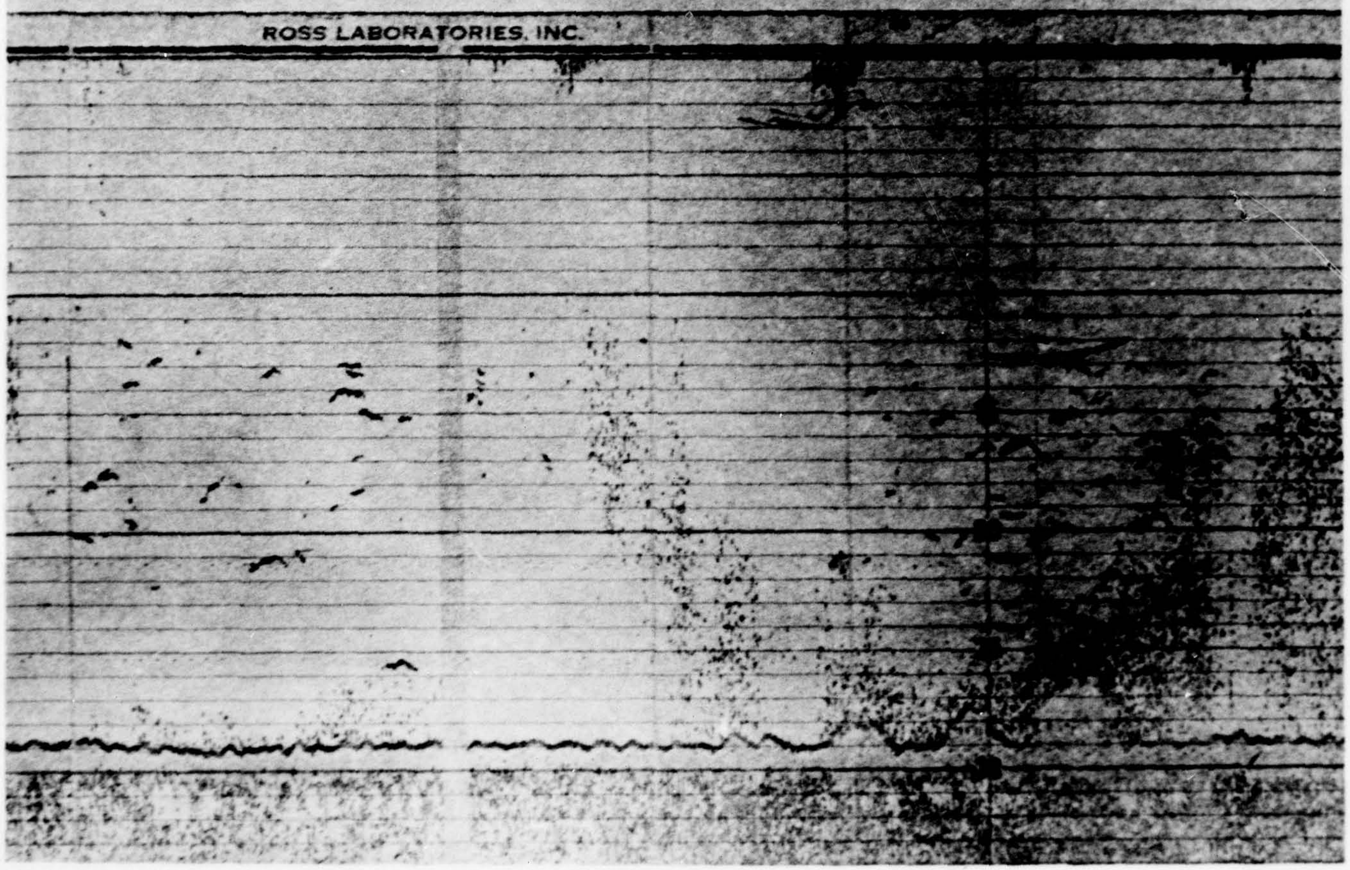


Figure 29

Fish response to disposal plume after approximately 14 minutes

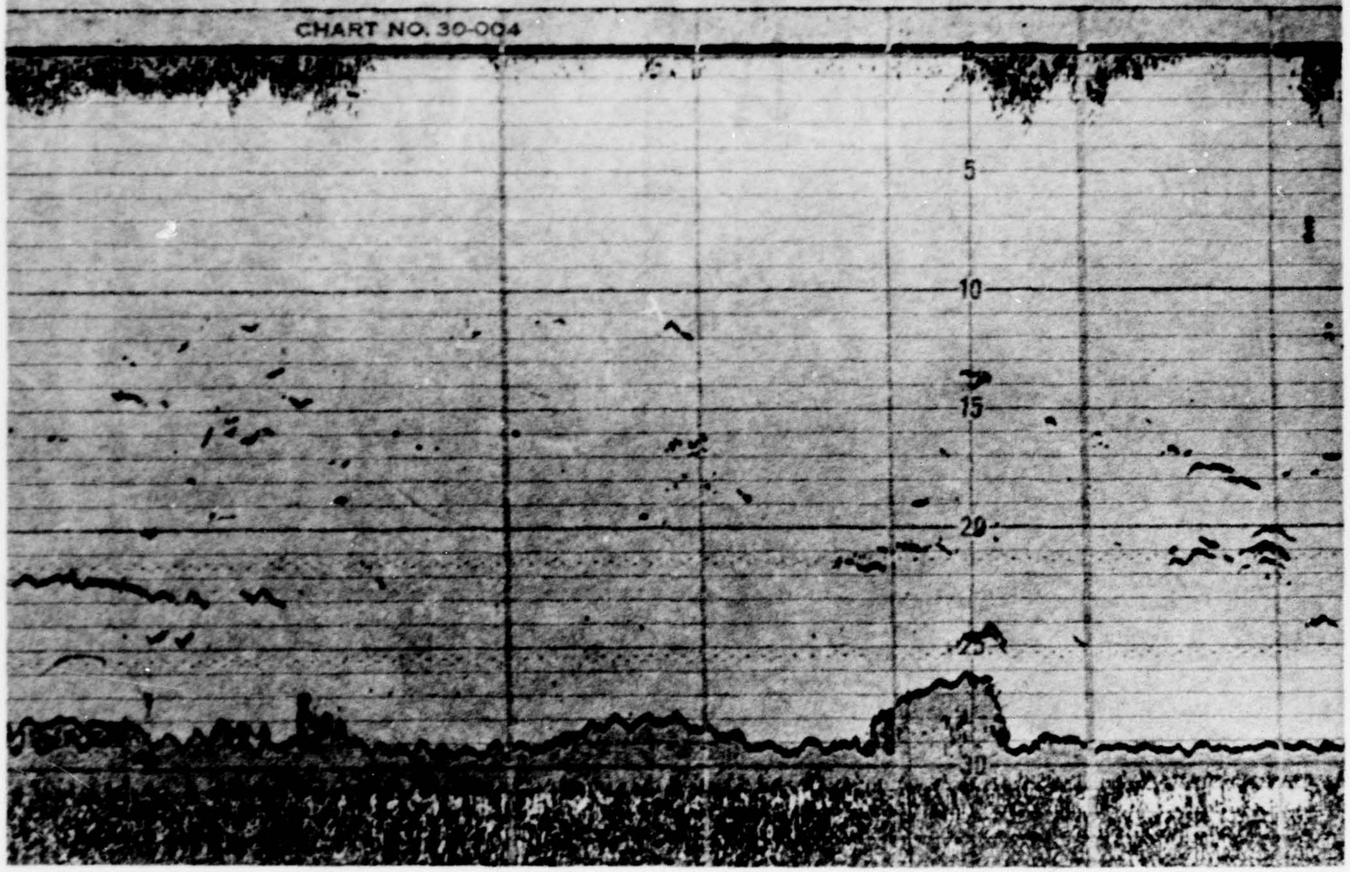
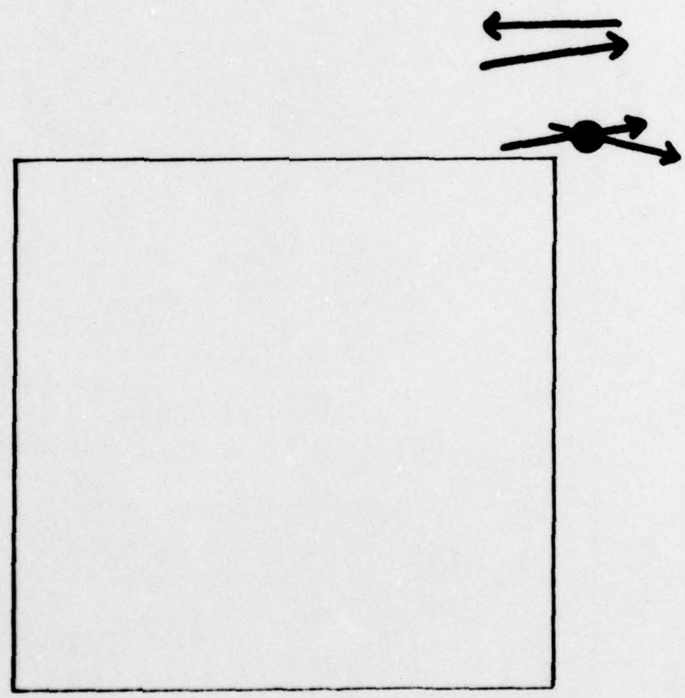


FIGURE 30

Mid-water Trawls at Station F8 During Disposal - 1976

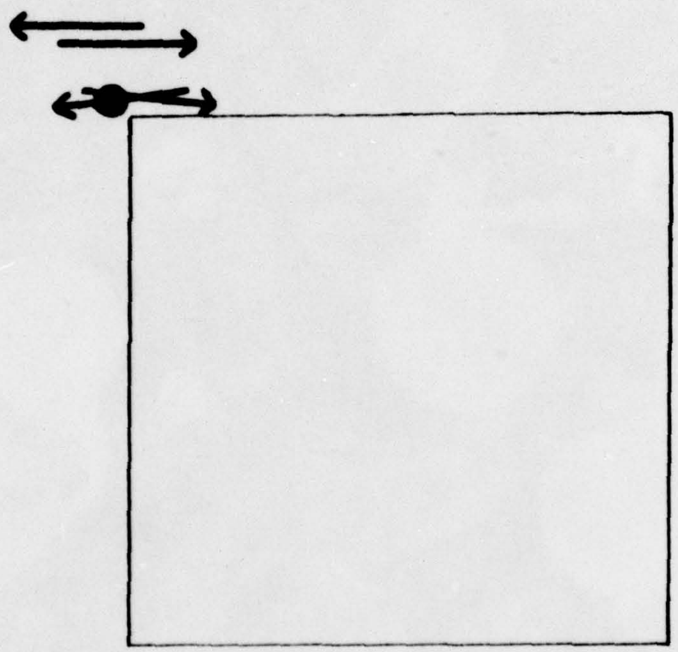


Direction of Trawl Run

Disposal Point

FIGURE 31

Mid-water Trawls at Station F7 During Disposal - 1976



Direction of Trawl Run

Disposal Point

Figure 32

Condition of eggs in containers lifted from station F-18

Figure 33

Condition of eggs in containers lifted from station F-7

After the disposal period

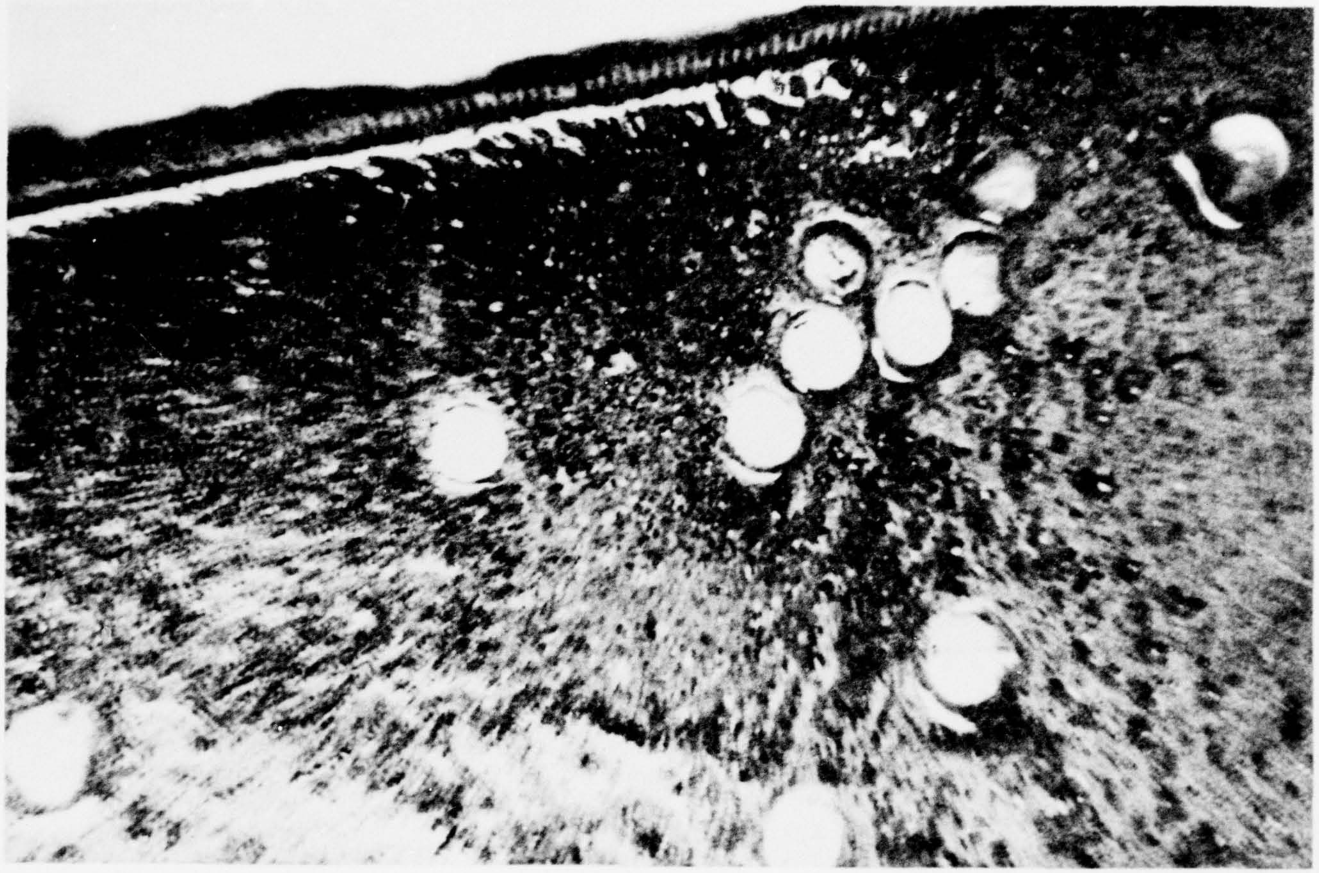


FIGURE 34

Monthly feeding behavior of offshore Yellow Perch

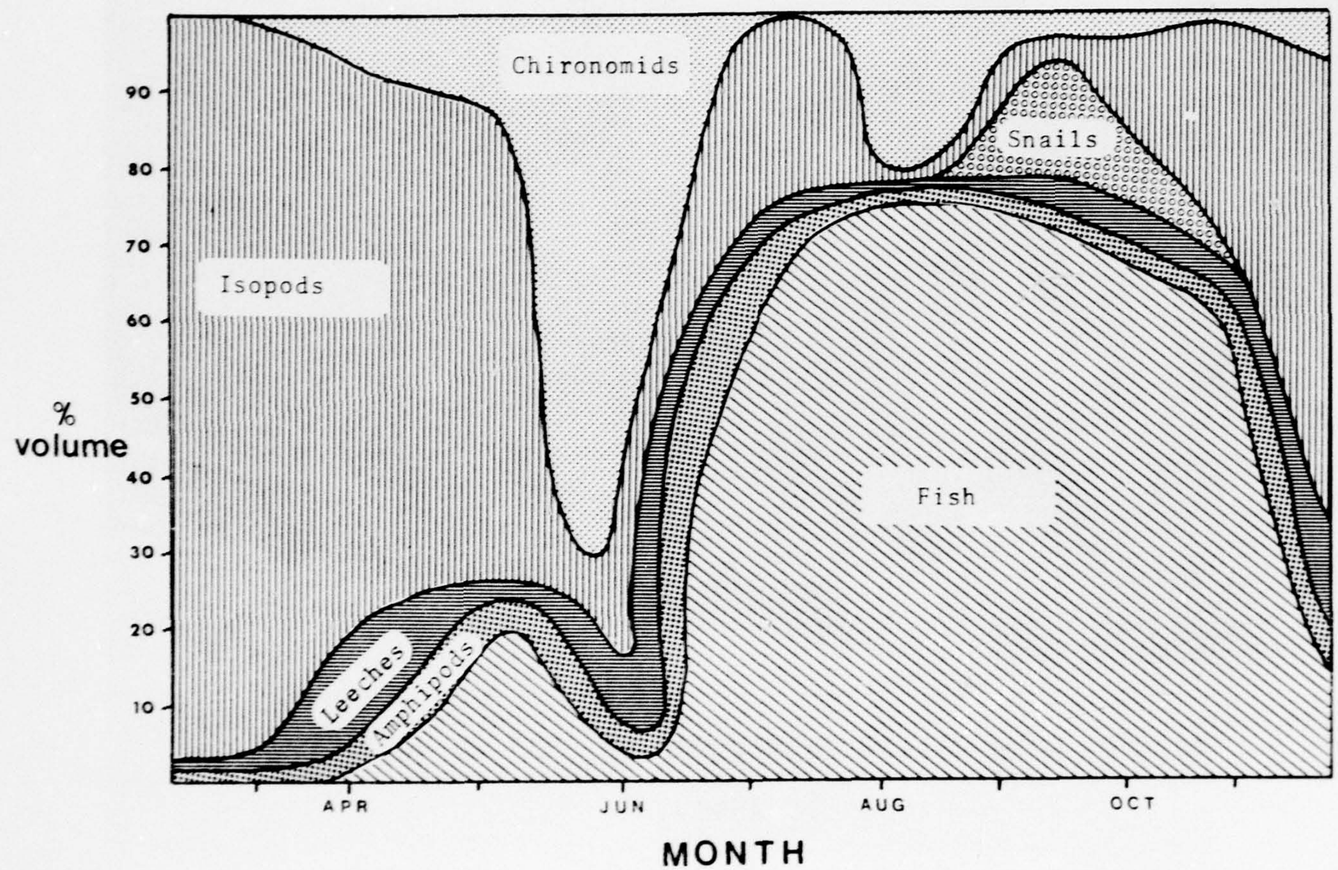
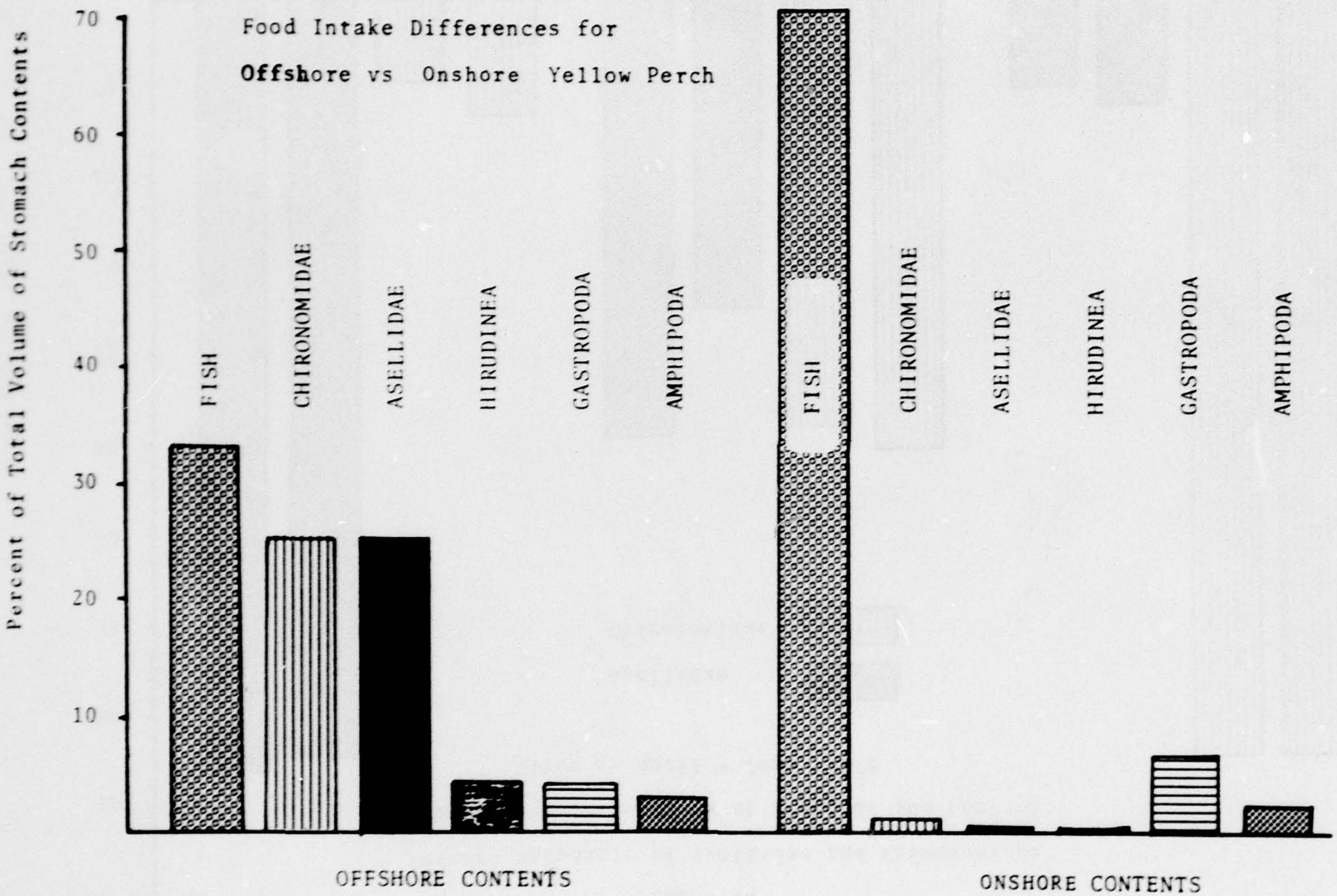


FIGURE 35



Food Intake Differences for
Offshore vs Onshore Yellow Perch
Percent of Total Volume of Stomach Contents
70
60
50
40
30
20
10
FISH
CHIRONOMIDAE
ASELLIDAE
HIRUDINEA
GASTROPODA
AMPHIPODA
FISH
CHIRONOMIDAE
ASELLIDAE
HIRUDINEA
GASTROPODA
AMPHIPODA
OFFSHORE CONTENTS
ONSHORE CONTENTS

FIGURE 36

Percent Abundance of Asellidae and Chironomidae in Yellow Perch Stomachs at Disposal and Control Sites -- April - June 1976

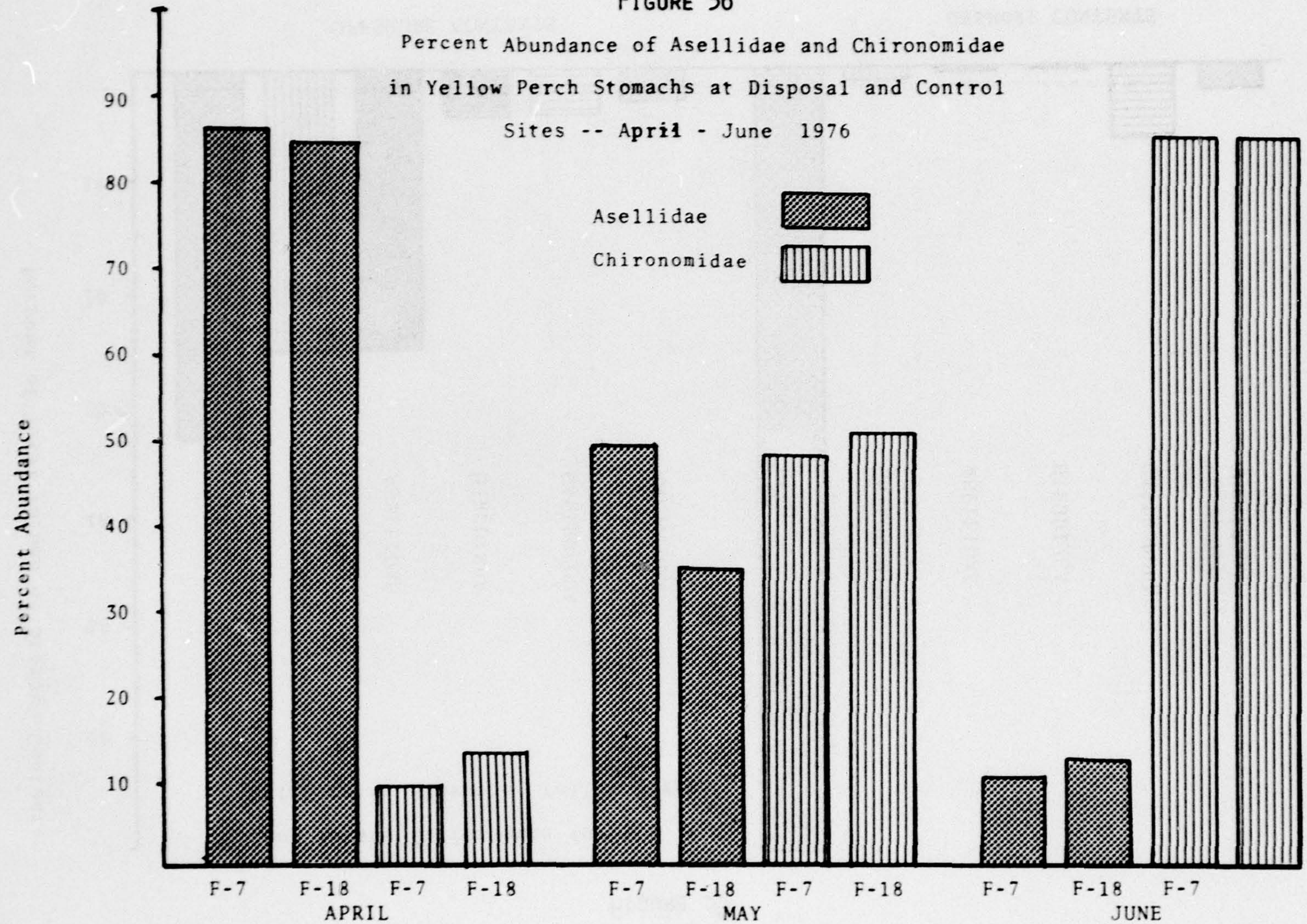


FIGURE 37

Predisposal Feeding Patterns,
Benthic Food Items Only in
Yellow Perch

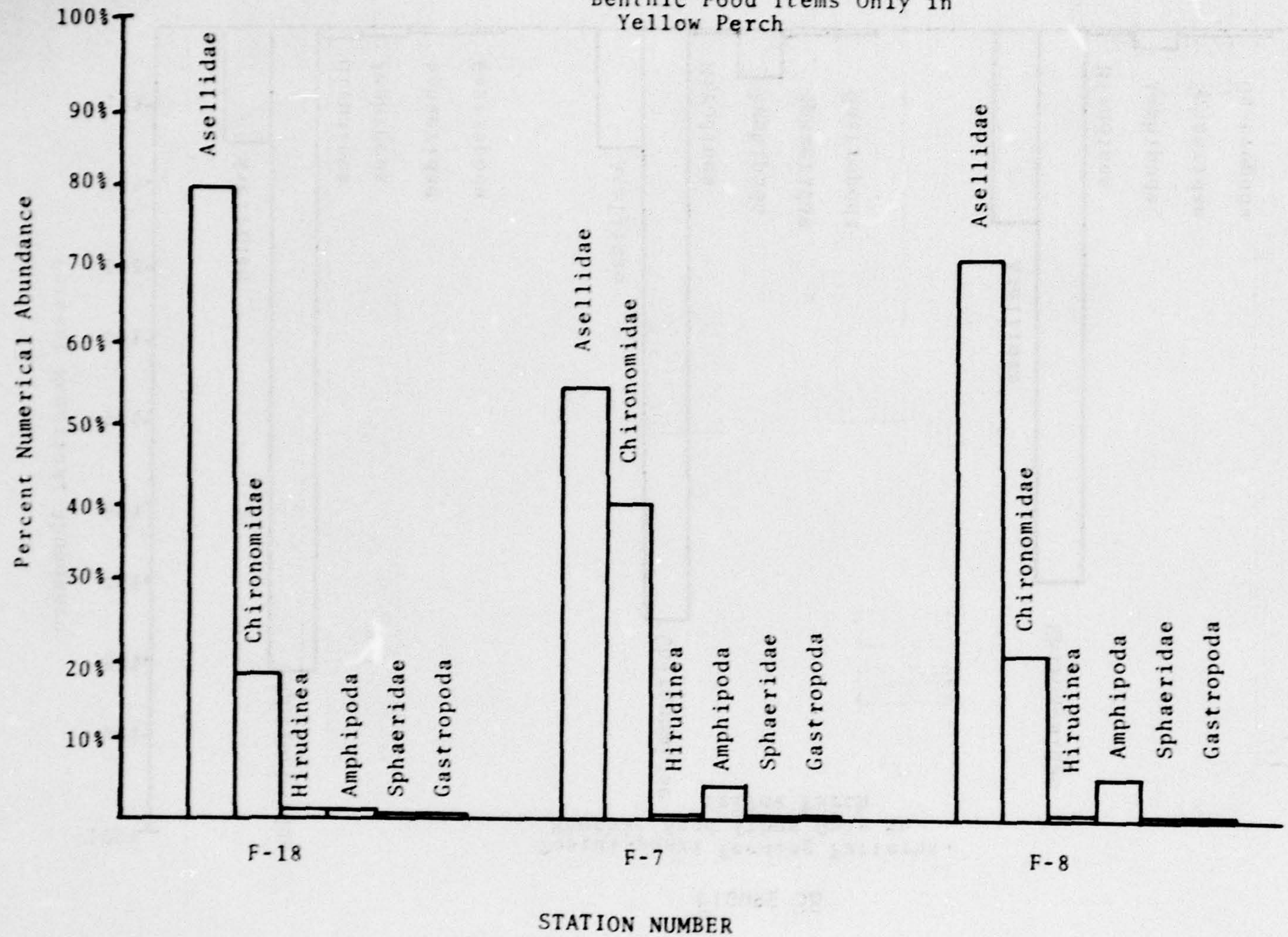


FIGURE 38

Postdisposal Feeding Patterns, Benthic Food Items Only in Yellow Perch

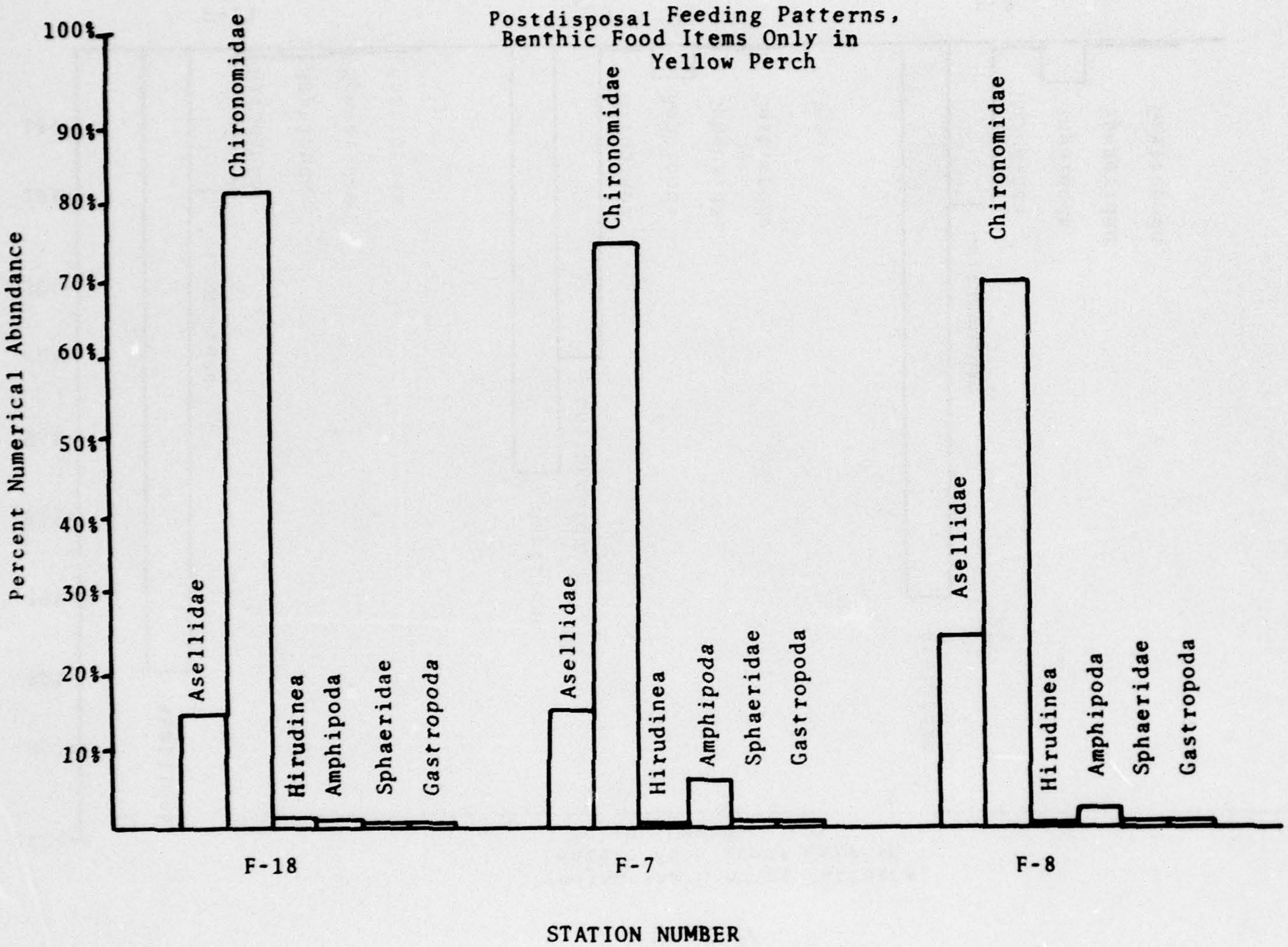
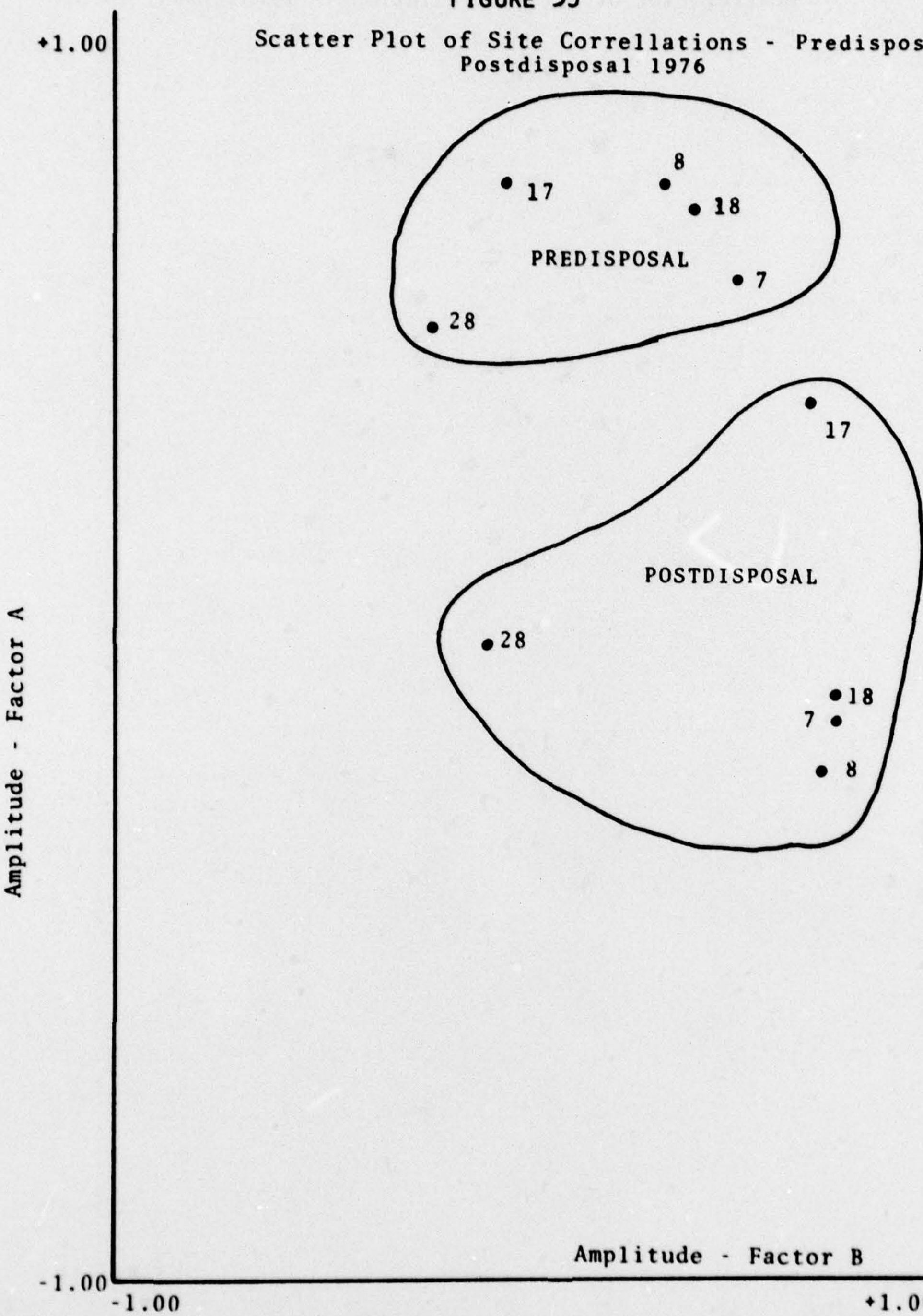


FIGURE 39

Scatter Plot of Site Correllations - Predisposal and Postdisposal 1976



Scatter Plot of Site Correllations - Before and After Disposal

FIGURE 40

Scatter Plot of Site Correllations - Predisposal 1976

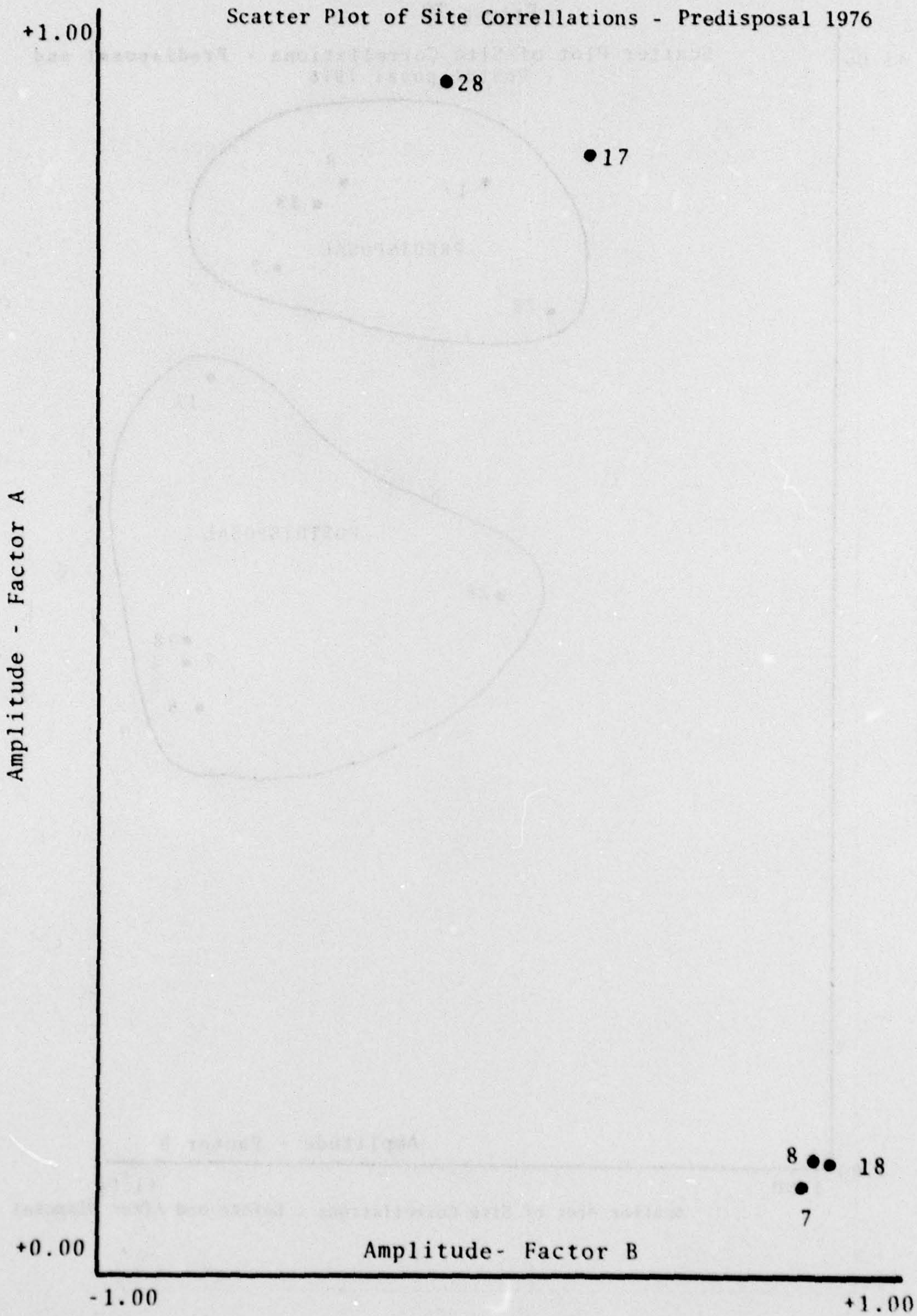
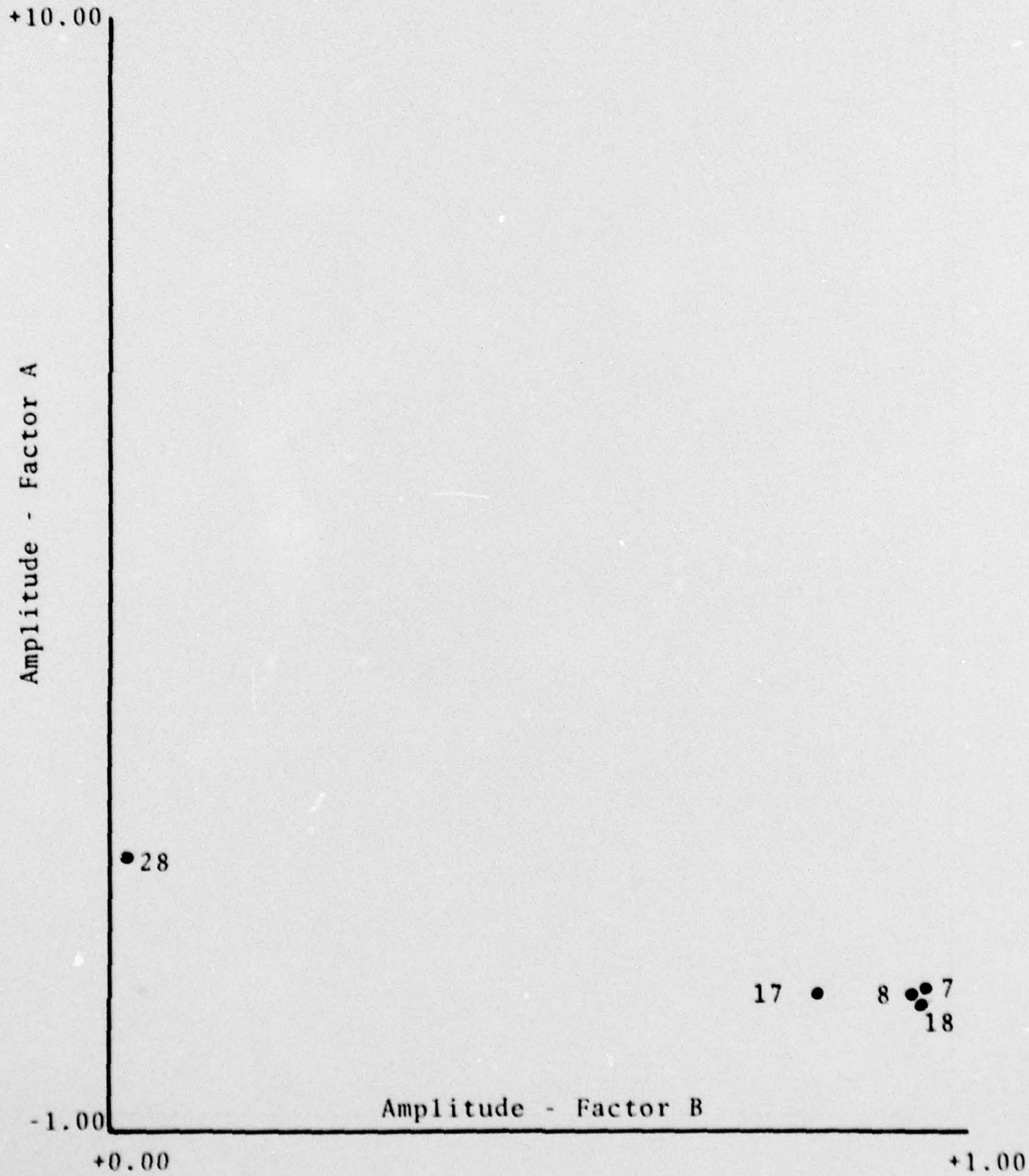


FIGURE 41

Scatter Plot of Site Correllations - Postdisposal 1976



In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Sweeney, Robert A

Aquatic disposal field investigations, Ashtabula River disposal site, Ohio; Appendix A: Planktonic communities, benthic assemblages, and fishery / by Robert A. Sweeney, Great Lakes Laboratory, State University College at Buffalo, Buffalo, New York. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

v, A-208, [116] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-42, Appendix A)

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Literature cited: p. A-83-A-87.

1. Aquatic environment. 2. Ashtabula River. 3. Benthic fauna. 4. Benthic flora. 5. Biota. 6. Dredged material. 7. Dredged material disposal. 8. Field investigations. 9. Lake Erie. 10. Plankton. 11. Waste disposal sites. I. Great Lakes Laboratory. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-42, Appendix A.

TA7.W34 no.D-77-42 Appendix A